THE

QUARTERLY JOURNAL

OF THE

GEOLOGICAL SOCIETY OF LONDON.

EDITED BY

THE ASSISTANT-SECRETARY OF THE GEOLOGICAL SOCIETY.

Quod si cui mortalium cordi et curæ sit non tantum inventis hærere, atque iis uti, sed ad ulteriora penetrare; atque non disputando adversarium, sed opere naturam vincere; denique non belle et probabiliter opinari, sed certo et ostensive scire; tales, tanquam veri scientiarum filii, nobis (si videbitur) se adjungant —*Novum Organum, Præfatio.*

VOLUME THE TWENTY-SIXTH.

1870.

PART THE FIRST.
PROCEEDINGS OF THE GEOLOGICAL SOCIETY.

LONDON:
LONGMANS, GREEN, READER, AND DYER.
PARIS: FRIED. KLINCKSIECK, 11 RUE DE LILLE; F. SAVY, 24 RUE HAUTEFEUILLE.
LEIPZIG: T. O. WEIGEL.

SOLD ALSO AT THE APARTMENTS OF THE SOCIETY.

MDCCCLXX.

List

OF THE

OFFICERS

OF THE

GEOLOGICAL SOCIETY OF LONDON.

Elected February 18, 1870.

President.

Joseph Prestwich, Esq., F.R.S.

Vice-Presidents.

Sir P. de M. G. Egerton, Bart., M.P., F.R.S.
R. A. C. Godwin-Austen, Esq., F.R.S.
Warington W. Smyth, Esq., M.A., F R.S.
Sir Charles Lyell, Bart., F.R.S.

Secretaries.

P. Martin Duncan, M.B. Lond., F.R.S.
John Evans, Esq., F.R.S., F.S.A.

Foreign Secretary.

Prof. D. T. Ansted, M.A., F.R.S.

Treasurer.

J. Gwyn Jeffreys, Esq., F.R.S.

COUNCIL.

Prof. D. T. Ansted, M.A., F.R.S.
W. Carruthers, Esq., F.L.S.
W. Boyd Dawkins, Esq., M.A., F.R.S.
P. Martin Duncan, M.B. Lond., F.R.S.
Sir P. de M. G. Egerton, Bart., M.P., F.R.S.
John Evans, Esq., F.R.S., F.S.A.
J. Wickham Flower, Esq.
David Forbes, Esq., F.R.S.
Captain Douglas Galton, C.B., F.R.S.
R. A. C. Godwin-Austen, F.R.S.
Harvey B. Holl, M.D.
J. Whitaker Hulke, Esq., F.R.S.
Prof. T. H. Huxley, LL.D., F.R.S.
J. Gwyn Jeffreys, Esq., F.R.S. & L.S.
Sir Charles Lyell, Bart., D.C.L., F.R.S.
George Maw, Esq., F.L.S.
John Carrick Moore, Esq., M.A., F.R.S.
Prof. John Morris.
Joseph Prestwich, Esq., F.R.S.
Warington W. Smyth, Esq., M.A., F.R.S.
Rev. W. S. Symonds, M.A.
Rev. Thomas Wiltshire, M.A., F.L.S.
Henry Woodward, Esq., F.Z.S.

Assistant-Secretary, Librarian, and Curator.

W. S. Dallas, Esq., F.L.S.

Clerk.

Mr. W. W. Leighton.

Library Assistant.

Mr. F. H. Waterhouse.

TABLE OF CONTENTS.

PART I.—ORIGINAL COMMUNICATIONS.

LIST OF THE FOSSILS FIGURED AND DESCRIBED IN THIS VOLUME.

[In this list, those fossils the names of which are printed in Roman type have been previously described.]

Name of Species.	Formation.	Locality.	Page.
PLANTÆ.			
Osmundites Dowkeri. Pl. xxiv. f. 1–3, Pl. xxv. f. 1, 3, & 4	Lower Eocene...	Herne Bay	352
PROTOZOA.			
Purisophonia Clarkei. Pl. xvii. f. 1...	Jurassic (?)	Queensland	235
Cristellaria acutauricularis, var. *longicostata*	Jurassic (?)	Wollumbilla	242
CŒLENTERATA.			
(*Anthozoa.*)			
Amphihelia incrustans. Pl. xx. f. 6	Tertiary	S. Australia	304
Antillia lens. Pl. xx. f. 12	Tertiary	S. Australia	306
Balanophyllia campanulata. Pl. xxi. f. 1	Tertiary	S. Australia	302
—— *seminuda.* Pl. xxi. f. 2	Tertiary	S. Australia	302
—— *armata.* Pl. xxi. f. 3	Tertiary	S. Australia	302
—— *Selwyni.* Pl. xxi. f. 4	Tertiary	S. Australia	303
—— *fragilis.* Pl. xxi. f. 5	Tertiary	S. Australia	303
—— australiensis. Pl. xxi. f. 6 ...	Tertiary	S. Australia	303
—— cylindrica. Pl. xxi. f. 7	Tertiary	S. Australia	304
—— *Ulrichi.* Pl. xxi. f. 8	Tertiary	S. Australia	304
—— *tubiliformis.* Pl. xxi. f. 9 ...	Tertiary	S. Australia	304
Caryophyllia viola. Pl. xix. f. 1 ...	Tertiary	S. Australia	295
Conosmilia elegans. Pl. xx. f. 5 ...	Tertiary	S. Australia	305
—— anomala. Pl. xx. f. 10.........	Tertiary	S. Australia	305
—— striata. Pl. xx. f. 9	Tertiary	S. Australia	305
—— *lituolus.* Pl. xx. f. 11	Tertiary	S. Australia	305
Conotrochus M'Coyi. Pl. xix. f. 7...	Tertiary	S. Australia	298
—— typus. Pl. xix. f. 8	Tertiary	S. Australia	298
Cycloseris tenuis. Pl. xx. f. 8	Tertiary	S. Australia	301
Deltocyathus italicus. Pl. xix. f. 4	Tertiary	S. Australia	297

MOLLUSCA (*continued*).

Brachiopoda (*continued*).

(*Lamellibranchiata*.)

MOLLUSCA (*continued*).

Lamellibranchiata (*continued*).

Name of Species.	Formation.	Locality.	Page.
Mya Maccoyi. Pl. xiii. f. 8	Jurassic (?)	Victoria	253
Mytilus rugo-costatus. Pl. xiii. f. 2	Jurassic (?)	Wollumbilla	252
—— *planus.* Pl. xiii. f. 3	Jurassic (?)	Wollumbilla	252
—— *inflatus.* Pl. xiii. f. 4	Jurassic (?)	Wollumbilla	252
Myacites Sanfordii. Pl. xiii. f. 9	Jurassic (?)	W. Australia	253
—— *planus.* Pl. xii. f. 10	Jurassic (?)	Wollumbilla	254
Nucula Cooperi. Pl. xii. f. 8	Jurassic (?)	Wollumbilla	254
—— *truncata.* Pl. xii. f. 9	Jurassic (?)	Wollumbilla	254
—— *ungulella.* Pl. xxvi. f. 11	Middle Lias	Gloucestershire	407
Panopæa rugosa. Pl. xiii. f. 7	Jurassic (?)	Bungeeworgorai Creek	253
Pecten (?) *æquilineatus.* Pl. xi. f. 11	Jurassic (?)	Wollumbilla	248
—— *socialis.* Pl. xi. f. 9	Jurassic (?)	Wollumbilla	248
—— *greenoughiensis.* Pl. xi. f. 10	Jurassic (?)	W. Australia	248
—— *fimbriatus.* Pl. xi. f. 8	Jurassic (?)	Wollumbilla	248
Perna gigantea	Jurassic (?)	Wollumbilla	249
Tancredia plana. Pl. xiii. f. 13	Jurassic (?)	Wollumbilla	254
Teredo australis. Pl. xii. f. 11	Jurassic (?)	W. Australia	255
Thracia Wilsoni. Pl. xiv. f. 8	Jurassic (?)	Amby River, Bungeeworgorai	254
Trigonia Moorei. Pl. xiv. f. 9, 10	Jurassic (?)	Wollumbilla	255
—— *lineata.* Pl. xiii. f. 12	Jurassic (?)	Wollumbilla	255
Venus, sp. Pl. xxxiv. f. 7	Pliocene	Suffolk	502

(*Gasteropoda.*)

Name of Species.	Formation.	Locality.	Page.
Actæon Hochstetteri. Pl. x. f. 19	Jurassic (?)	Wollumbilla	256
—— *depressus.* Pl. x. f. 20	Jurassic (?)	Wollumbilla	256
Actæonina canariensis	Middle Lias	Gloucestershire	405
Cassidaria, sp. Pl. xxxiv. f. 8 & 9	Pliocene	Suffolk	500
Cerithium greenoughiensis. Pl. x. f. 22	Jurassic (?)	Greenough District	256
—— *ibex.* Pl. xxvi. f. 8	Middle Lias	Gloucestershire	405
—— *Slatteri.* Pl. xxvi. f. 7	Middle Lias	Gloucestershire	406
Chemnitzia crassicosta. Pl. xxvi. f. 6	Lower Lias	Gloucestershire	402
Conus Dujardinii (?). Pl. xxxiv. f. 5	Pliocene	Suffolk	500
Delphinula reflecta. Pl. x. f. 21	Jurassic (?)	Wollumbilla	256
Dentalium lineatum	Jurassic (?)	Wollumbilla	256
—— *limatulum.* Pl. xxvi. f. 1	Lower Lias	Gloucestershire	402
Exelissa numismalis. Pl. xxvi. f. 5	Middle Lias	Gloucestershire	403
Littorina biornata. Pl. xxvi. f. 17	Middle Lias	Gloucestershire	404
Natica variabilis. Pl. x. f. 15	Jurassic (?)	Wollumbilla	256
—— *ornatissima.* Pl. x. f. 16	Jurassic (?)	Wollumbilla	257
Patella sabrina	Lower Lias	Gloucestershire	402
Pleurotomaria raricostati. Pl. xxvi. f. 9 & 9*a*	Lower Lias	Gloucestershire	401
Rissoina australis. Pl. x. f. 23	Jurassic (?)	Wollumbilla	257
Straparolus Wrightianus. Pl. xxvi. f. 23	Middle Lias	Gloucestershire	404
—— *bellulus.* Pl. xxvi. f. 22	Middle Lias	Gloucestershire	404
—— *aratus.* Pl. xxvi. f. 21	Middle Lias	Gloucestershire	404
Tornatella capricorni. Pl. xxvi. f. 18	Middle Lias	Gloucestershire	405
Trochus Thetis. Pl. xxvi. f. 4	Middle Lias	Gloucestershire	403

EXPLANATION OF THE PLATES.

ERRATA ET CORRIGENDA.

Page 417, line 9, *after* " Chairman" *insert* " (Sir. P. Egerton)."
,, 468, line 11, *after* " Chairman" *insert* " (R. A. C. Godwin-Austen, Esq.)."
,, 533, line 24, *dele* " valley."
,, 572, Explanation of Plate XXXIX., *add* " two-thirds natural size."
,, ,, ,, XL., *add* " natural size."

GEOLOGICAL SOCIETY OF LONDON.

ANNUAL GENERAL MEETING, FEB. 18, 1870.

REPORT OF THE COUNCIL FOR 1869.

The Council of the Geological Society, in presenting their Report for the year 1869, have again to congratulate the Fellows on the continued prosperity of the Society, although from the numerous deaths which have taken place among the Fellows, their number has not increased so much even as last year.

The number of new Fellows elected is 54, of whom 44 paid their fees before the end of the year, making, with 8 previously elected Fellows who paid their fees in 1869, an effective increase of 52 Fellows. But against this we have to place the loss of 25 Fellows by death, and of 9 by resignation, giving a net increase of 18 ordinary Fellows. The number of Contributing Fellows is now 511.

The death of 2 Foreign Members and of 1 Foreign Correspondent was announced in 1869.

The total number of Fellows and Foreign Members and Correspondents of the Society at the end of 1868 was 1204; and at the end of 1869, 1222.

The Council have much gratification in reporting that the Income of the year 1869 has exceeded the Expenditure by £98 15*s.* 9*d.*, notwithstanding the investment of £200 in the purchase of £214 3*s.* 10*d.* of 3 per cent. Consols. The total Receipts were £1966 11*s.* 5*d.*, and the total Expenditure £1867 15*s.* 8*d.*

With regard to the Arrears of Contributions, noticed in the Report of the Auditors as being due from Fellows, the amount of which appears to be considerable, it may be observed that about one-third of this amount is due from Fellows who have been for some time resident abroad, or whose address cannot be discovered; and a considerable part of the rest is irrecoverable, although every endeavour has been made to obtain payment.

The Council have to announce the completion of Vol. XXV. of the Quarterly Journal, and the publication of the first part of Vol. XXVI.

The Council have also to announce the publication of the new Edition of Mr. Ormerod's Index to the various publications of the Society, which is brought down to the end of Vol. XXIV. of the Quarterly Journal. The delay in the production of this work is due to the detection of certain errors, mostly uncorrected misprints in the first edition of the Index, which rendered the collation of all the references necessary.

The Council have awarded the Wollaston Medal to M. G. P. Deshayes, Professor of Natural History in the Musée d'Histoire Naturelle, Paris, in testimony of appreciation of his valuable palæontological labours, especially his recently completed magnificent work on the Invertebrate Fossils of the Paris basin.

The Balance of the proceeds of the Wollaston Fund has been awarded to M. Marie Rouault, Directeur Conservateur du Musée Géologique de Rennes, in aid of those valuable researches upon the Palæontology of the Silurian and Devonian rocks of Brittany which he has already carried on for years with most important results, notwithstanding the pressure of great difficulties.

Report of the Library and Museum Committee, 1869–1870.

Library.

The Standing Library-Committee have continued from time to time to make additions to the Library by the purchase of such books as they thought would prove useful to the Fellows; and amongst these the following valuable works may be quoted:—

Schimper's 'Traité de Paléontologie Végétale,' the first volume, with a folio Atlas of 50 Plates; the 'Histoire Naturelle des Coralliaires,' by MM. Milne-Edwards and Haime, in 3 volumes, and the 'Histoire Naturelle des Echinodermes,' by MM. Dujardin and Hupé, forming part of the 'Suites à Buffon;' Heer's 'Miocene Baltische Flora;' Ooster's 'Protozoe Helvetica,' Parts 1 and 2; Ooster's 'Corallien de Wimmis;' Dumortier's 'Etudes paléontologiques sur les Dépots Jurassiques du Bassin du Rhone;' and the 'Voyage Géologique dans les Républiques de Guatemala et de Salvador,' by MM. A. Dollfus and E. Mont-Serrat; also the continuations of the following important publications: Eichwald's 'Lethæa Rossica,' Quenstedt's 'Petrefactenkunde Deutschlands,' the 'Palæontographica,' the 'Paléontologie Française,' and Alph. Milne-Edwards's 'Recherches Anatomiques et Paléontologiques pour servir à l'Histoire des Oiseaux Fossiles de la France.'

A great number of valuable donations have been made to the Library during the past year, and these include, besides periodicals

and the publications of Learned Societies, many separate works of importance, such as:—

A portion of Pictet's 'Matériaux pour la Paléontologie Suisse,' containing a Monograph of the Valangian beds of Arzier, by MM. Pictet and de Loriol; M. Elie de Beaumont's 'Rapport sur les progrès de Stratigraphie en France;' Sir Proby T. Cautley's 'Report on the Ganges Canal,' in 3 vols. 8vo, with a large folio Atlas of Plates, 2 copies, one presented by the author, the other by W. T. Thornton, Esq.; the Publications of the Musée Teyler, containing palæontological Memoirs by M. T. C. Winkler; 'Matériaux pour la Carte géologique de la Suisse,' Livr. VI., containing a notice of the Jurassic strata of the Cantons de Vaud and Neuchâtel, by M. Aug. Jaccard; E. Favre's 'Description des Mollusques Fossiles de la Craie des environs de Lemberg en Galicie;' M. de Tchihatcheff's 'Asie Mineure, Géologie,' Parts 2 and 3; Dr. Bigsby's 'Thesaurus Siluricus' (2 copies); the fifth and concluding volume of M. von Kokscharow's 'Materialien zur Mineralogie Russlands;' and Mr. R. B. Smyth's 'Gold Fields and Mineral Districts of Victoria.'

A good many Maps and Plans have been added to the Society's Collection; they include the Maps of the Geological Surveys of Victoria (3 sheets, with 2 plates of sections, &c.), Austria (2 sheets), Sweden (5 sheets, with 5 parts of descriptions), and Switzerland (2 sheets); also Sir W. E. Logan's Geological Map of Canada (in 8 sheets), and the Maps of the Geological Society of the Middle Rhine (Lauterbach-Salzschlirf Section). Besides these the Society has received a great number of the Maps of the Ordnance Survey, and of Charts and Plans of sea-coasts, harbours, and channels in various parts of the world, from the French Dépôt de la Marine.

During the past year the Library has been completely examined and put in good working order; the Catalogue has also been carefully collated with the Books and corrected. New boxes have been provided for the loose numbers of the current periodicals.

Museum.

Some donations of specimens illustrative of papers read before the Society have been received. Several small Collections of Fossils which had been lying loose about the Museum, have been placed in new Trays and Store-boxes.

THOS. WILTSHIRE.
J. GWYN JEFFREYS.

Comparative Statement of the Number of the Society at the close of the years 1868 *and* 1869.

	Dec. 31, 1868.		Dec. 31, 1869.
Compounders	206	......	210
Contributing Fellows......	487	......	511
Non-contributing Fellows..	430	......	420
	1123		1141
Honorary Members	3	......	3
Foreign Members	41	......	39
Foreign Correspondents....	37	......	39
	1204		1222

General Statement explanatory of the Alteration in the Number of Fellows, Honorary Members, &c., at the close of the years 1868 *and* 1869.

Number of Compounders, Contributing and Non-contributing Fellows, December 31, 1868..............................			1123
Add Fellows elected during former year, and paid in 1869			8
Add Fellows elected and paid in 1869			44
			1175
Deduct Compounders deceased..............		8	
Contributing Fellows deceased		8	
Non-contributing Fellows deceased....		9	
Contributing Fellows resigned		9	
			34
			1141
Number of Honorary Members, Foreign Members, and Foreign Correspondents, December 31, 1868		81	
Add Foreign Correspondents elected		3	
		84	
Deduct Foreign Members deceased	2		
Foreign Correspondents deceased..	1		
		3	
			81
			1222

Deceased Fellows.

Compounders (8).

A. K. Barclay, Esq.
Rev. J. Barlow.
Sir C. W. Dilke, Bart.
R. Fort, Esq.
T. Graham, Esq.
P. Roget, M.D.
J. W. Salter, Esq.
Sir T. Maryon Wilson, Bart.

Resident and other Contributing Fellows (8).

J. Dickinson, Esq.
J. Harris, Esq.
Sir J. V. Johnstone, Bart.
Rev. S. W. King.
C. W. Macrae, Esq.
R. N. Rubidge, M.B.
J. Simpson, Esq.
Rev. T. Wollaston.

Non-contributing Fellows (9).

Capt. Chenay.
W. Clarke, M.D.
J. D. Forbes, LL.D.
J. Hedley, Esq.
J. B. Jukes, Esq.
Rev. J. H. Randolph.
J. N. Saunders, Esq.
R. White, Esq.
Rev. W. Wilson.

Foreign Members (2).

M. le Vicomte d'Archiac.
Dr. Hermann von Meyer.

Foreign Correspondent (1).

Dr. B. Shumard.

Fellows Resigned (9).

Rev. S. Brooke.
H. Conybeare, Esq.
F. Hill, Esq.
R. H. Jarvis, Esq.
D. G. F. Macdonald, Esq.
W. H. Nevill, Esq.
G. Paddisen, Esq.
Rev. R. N. Russell.
N. T. Wetherell, Esq.

The following Personages were elected Foreign Correspondents during the year 1869.

Prof. F. Zirkel, of Kiel.
Dr. J. F. Brandt, of St. Petersburg.
Prof. A. E. Nordenskiöld, of Stockholm.

The following Persons were elected Fellows during the year 1869.

January 13th.—William Groome, Esq., B.A., St John's College, Cambridge.

—— 27th.—Arnold Lupton, Esq., Salter Gate, Chesterfield; and Dr. George Rogers, Longwood House, Bristol.

February 10th.—M. A. Tackhadakar, Esq., 3 St. George's Terrace, Regent's Park, N.W.; and Henry Spicer, Jun., Esq., 22 Highbury Crescent, N.

—— 24th.—Henry Cook, M.D., H.M. Bombay Medical Service; Lieut. W. Innes, R.E.; H. R. Moiser, Esq., Heworth Grange, York; R. Hill Tiddeman, Esq., B.A., Oriel College, Oxford; and Samuel Allport, Esq., Snow Hill, Birmingham.

March 10th.—Thomas Bloxam, Esq., F.C.S., Lecturer on Chemistry in Cheltenham College; and Joseph John Murphy, Esq., Old Forge, Dunmurry, Co. Antrim.

—— 24th.—Rev. Samuel Norwood, B.A., Royal Grammar School, Whalley, Lancashire.

April 14th.—Capt. William Price, M.P., Tibberton Court, Gloucester; Sir David Wedderburn, Bart., M.P., 17 Pall Mall; A. Rogers, Esq., Bombay Civil Service, Heath End House, Hampstead; W. E. Koch, Esq., 31 Oxford Square, Hyde Park; and Rev. James Kernahan, M.A., Ph.D. (Rostock), 50 Greenwood Road, Dalston.

April 28th.—Daniel Jones, Esq., Donington, Wolverhampton; and T. H. G. Wyndham, Esq., Fellow of Merton College, Oxford.

May 12th.—Francis Henry Brown, Esq., Bishwell, near Swansea; Samuel Jenkins, Esq., 13 Clement's Inn Passage, W.C.; Lieut. W. H. James, R.E., Brompton Barracks, Chatham; Charles Lambert, Esq., 3 Queen Street Place, E.C.; Gordon Broome, Esq., 1 Graham Street, S.W.; and Thomas William Gardner, Esq., Assoc. Inst. C.E., 10 St. Augustine's Road, Camden Square, N.W.

—— 26th.—E. Story, Esq., M.A., 3 King Edward Terrace, Liverpool Road, N.; F. W. Harmer, Esq., Heigham Grove, Norwich; and Henry J. Fotherby, M.D. Lond., 40 Trinity Square, Tower Hill, E.

June 9th.—William Shelford, Esq., Mem. Inst. C.E., 7 Westminster Chambers, Victoria Street, S.W.; E. Teschemacher, Esq., 1 Highbury Park, N.; G. L. Houstoun, Esq., Johnstone Castle, Johnstone, N.B.; and T. P. Barkas, Esq., Newcastle-on-Tyne.

—— 23rd.—G. H. Wollaston, Esq., Geological Survey of England and Wales; Richard Pearce, Esq., Swansea; Richard Moreland, jun., Esq., Old Street, E.C.; James N. Shoolbred, Esq., B.A., Assoc. Inst. C.E., 3 York Buildings, Dale Street, Liverpool; Fritz Gillman, Esq., 14 Ashley Place, Westminster, S.W.; and Richard Abbay, Esq., B.A., Fellow of Wadham College, Oxford.

November 10th.—E. Hartley, Esq., Geological Survey of Canada, Montreal.

—— 24th.—Robert A. Barker, M.D., Civil Medical Officer, Cachar, Bengal.

December 8th.—Charles E. De Rance, Esq., Geological Survey of

England and Wales; John E. Taylor, Esq., Hon. Secretary, Norwich Geological Society, Bracondale, Norwich; Rev. George Henslow, M.A., St. John's Parsonage, St. John's Wood, N.W.; C. J. A. Meyer, Esq., 8 Church Buildings, Clapham Common, S.W.; J. Harper, Esq., Claremont House, Chaucer Road, Dulwich, S.E.; John Yeats, LL.D., Clayton Place, Peckham, S.E.; J. S. Holden, M.D., Glenarm, co. Antrim; David Robertson, Esq., 4 Regent's Park Terrace, Glasgow; Walter Buller, Esq., E.L.S., Wanganui, New Zealand; and J. H. Collins, Esq., Royal Institution of Cornwall, Truro.

December 22nd.—John Hopkinson, Esq., 8 Lawn Road, Haverstock Hill, N.W.; Samuel John Sanders, Esq., M.A., Vice-Master of the Beds Middle Class School, Bedford; and Jabez Church, Esq., C.E., 17B Great George Street, S.W.

The following Donations to the Museum have been received since the last Anniversary Meeting.

Specimens of Rocks from Venezuela and Guyana; presented by Ralph Tate, Esq., F.G.S., and — Matthews, Esq.

Model of a large Gold Nugget from Sutherland; presented by Prof. Tennant, F.G.S.

Maps, Charts, etc. presented.

Geological Survey Maps of Victoria, Sheets 13 and 14 N.W., 26 S.E., and 2 Sheets of Sections and Explanations to Sheets 14 and 26; presented by the Director of the Geological Survey of Victoria.

Geological Survey Maps of Austria, Sheets 6 and 10, by F. Ritter von Hauer; presented by the author.

Geological Survey Maps of Sweden, Sheets 26–30, with 5 Parts of Description; presented by the Director, Prof. A. Erdmann.

Geological Survey Maps of Switzerland, Sheets 3 and 20; presented by the Swiss Geological Commission.

Geological Map of Canada (in 8 Sheets), by Sir W. E. Logan, F.G.S.; presented by the author.

Geological Map of the Lauterbach-Salzschlirf Section; presented by the Geological Society of the Middle Rhine.

Ordnance-Survey Maps, England, 1-inch scale, Sheets 106 S.W. and N.W., 107 N.E., S.W., and S.E., 108 S.W., and 109 N.W.; 6-inch scale, Middlesex, Sheets 1–10, 14, 15, 19, 20, 24, and 25; Devonshire, Sheets 116, 122, 124, 128, and 130, and Titles for Cumberland, Durham, Northumberland, and Westmoreland; and County Index for Northumberland: Scotland, 1-inch scale, Sheet 25; 6-inch scale, Aberdeen, 41, 49, 50, 64, 65, 67, 72–74, 76–79, 83–85, 87–91, 93, 96–100, 102–108, 110, and 111; Argyle, 162, 163, 172, 173, 182–184, 193–195, 203, 204, 214–216, 225–228, 237, 238, 241, 242, 244, and 248–266, and Titles for Ayrshire, Forfarshire, Perthshire and Clackmannan, and Selkirk; and

County Indexes for Perth and Stirling; and Ireland, Sheets 17, 22, 40, and 41; presented by the Secretary of State for War.
Charts and Plans presented by the French Depôt de la Marine.

The following Lists contain the Names of Persons and Public Bodies from whom the Society has received Donations to the Library and Museum since the last Anniversary Meeting, February 19, 1869.

I. List of Societies and Public Bodies from whom Donations of Books have been received since the last Anniversary Meeting.

Basel, Natural-History Society of.
Bath, Natural-History and Antiquarian Field Club of.
Berlin. German Geological Society.
——. Society of Naturalists at.
——. Royal Prussian Academy.
Berwick. Berwickshire Naturalists' Field Club.
Bordeaux, Linnean Society of.
——, Society of Physical and Natural Sciences of.
Boston, Public Library of.
——, Society of Natural History of.
Breslau. Silesian Society.
Brussels. Royal Academy of Belgium.
——, Royal Observatory of.

Caen. Linnean Society of Normandy.
Calcutta. Asiatic Society of Bengal.
Cambridge, Philosophical Society of.
Canadian Institute.
Christiania, Royal Academy of.
——, University of.
Copenhagen. Royal Danish Academy.
Cornwall and Devonshire Miners' Association.

Darmstadt. Geological Society of the Middle Rhine.
Devonshire. Scientific Association.
Dorpat, Natural-History Society of.
Dresden, (Isis) Natural-History Society of.
Dublin. Royal Dublin Society.
——. Royal Geological Society of Ireland.
——. Royal Irish Academy.

East India Association.
Edinburgh, Geological Society of.
——, Royal Physical Society of.

Florence. Italian Society of Natural Sciences.

Geneva, Physical and Natural-History Society of.
German Scientific Association.
Giessen. Upper-Hessian Society.
Glasgow, Geological Society of.

Haarlem, Society of Sciences of.
——. Musée Teyler.
Halifax. Nova-Scotian Institute of Natural Science.
Hanau. Wetteravian Society of Natural History.
Harvard College.
Heidelberg, Natural-History and Medical Society of.

Indian Government.

Lausanne. Vaudoise Society of Natural Sciences.

Leeds, Literary and Philosophical Society of.
Liverpool, Geological Society of.
——. Historic Society of Lancashire and Cheshire.
London, Anthropological Society of.
——, Art Union of.
——. British Association.
——. Chemical Society.
——. Geological Survey.
——. Geologists' Association.
——. Institute of Actuaries.
——. Institution of Civil Engineers.
——. Linnean Society.
——. Metropolitan Board of Works.
——. Palæontographical Society.
——. Photographic Society.
——. Quekett Microscopical Club.
——. Ray Society.
——. Royal Agricultural Society of England.
——. Royal College of Surgeons.
——. Royal Geographical Society.
——. Royal Horticultural Society.
——. Royal Institution.
——. Royal Society.
——. Society of Arts.
——. Victoria Institute.
——. War Office.
——, Zoological Society of.

Maine, Commissioners of Fisheries of.
Manchester, Geological Society of.
——, Literary and Philosophical Society of.
Melbourne. Geological Survey of Victoria.
——. Mining Survey of Victoria.
Milan. Italian Society of Natural Sciences.
Milan. Royal Lombard Institute.
Montreal, Natural-History Society of.
Moscow, Imperial Society of Naturalists of.
Munich, Academy of Sciences of.

Neuchâtel, Society of Natural Sciences of.
Newcastle-on-Tyne. Natural-History Society of Northumberland and Durham.
New York, Lyceum of Natural History of.
——, State Cabinet of.
New Zealand, Geological Survey of.
——, Government of.
—— Institution.

Offenbach, Natural-History Society of.

Palermo, Institute of Natural Sciences of.
Paris. Academy of Sciences.
——. Dépôt de la Marine.
——. Geological Society of France.
Philadelphia, Academy of Natural Sciences of.
——. American Philosophical Society.
Plymouth Institution.
Portland, Society of Natural History of.
Puy. Society of Agriculture, Arts, &c.

Salem. Peabody Academy of Sciences.
——. Essex Institute.
St. Petersburg, Academy of Sciences of.
Stockholm. Royal Swedish Academy.
Stuttgart. Natural-History Society of Württemberg.

Switzerland, Natural-History Society of.
Sydney. Royal Society of New South Wales.

Teignmouth. Teign Naturalists' Field Club.
Turin, Royal Academy of Sciences of.

United States, Patent Office of.

Vienna, Imperial Academy of Sciences of.
——, Geological Institute of.

Warwickshire Naturalists' Field Club.
Woolhope Naturalists' Field Club.
Washington, National Academy of Sciences of.
——. Smithsonian Institution.

II. List containing the names of Persons from whom Donations to the Library and Museum have been received since the last Anniversary Meeting.

Academy, Editors of the.
Agassiz, Prof. L., F.M.G.S.
Agriculture, United States Commissioner of.
American Journal of Science, Editors of the.
American Naturalist, Editors of the.
Annales des Mines, Editors of the.
Ansted, Prof. D. T., F.G.S.
Athenæum, Editor of the.

Baily, W. H., Esq., F.G.S.
Barrande, M. J., F.M.G.S.
Bauerman, H., Esq., F.G.S.
Beaumont, Prof. Elie de, F.M.G.S.
Bianconi, M. G. G.
Bigsby, Dr., F.G.S.
Boccardo, G.
Bolton, John, Esq.
Brayley, Prof. E. W., F.G.S.
Brodie, Rev. P. B., F.G.S.
Brown, R., Esq.
Burmeister, Dr. H.

Canadian Journal, Editors of the.
Capanema, M. G. S.
Cartailhac, M.
Cautley, Sir Proby T., F.G.S.
Ciofalo, M. S.
Chemical News, Editors of the.
Christy, H., Esq., Executors of the late.
Colliery Guardian, Editor of the.
Cotteau, M. G.
Cowell, Mr. S. H.
Credner, M. H., F.C.G.S.
Croll, J., Esq.

Dallas, W. S., Esq.
D'Ancona, M. C.
Darwin, C., Esq., F.G.S.
Daubrée, M., F.M.G.S.
Davidson, T., Esq., F.G.S.
Dutton, F. S., Esq.

Eckman, M.
Ehrenberg, Prof. C. G., F.M.G.S.
Enniskillen, Earl of, F.G.S.
Erdmann, Dr.
Erioni, M. A.
Evans, John, Esq., F.G.S.

Fairman, E. St. John, Esq., F.G.S.
Favre, M. A., F.C.G.S.
Favre, M. E.
Fischer, Dr. C. F.
Fisher, Rev. O., F.G.S.
Fuchs, M. T.

Geikie, A., Esq., F.G.S.
Geological and Natural-History Repertory, Editor of the.

Geological Magazine, Editors of the.
Gibb, Sir Duncan, F.G.S.
Grewingk, M. C.
Griesbach, M. K.

Haidinger, Prof. W. von, F.M.G.S.
Halloy, M. J. J. d'Omalius d', F.M.G.S.
Hébert, M. E., F.C.G.S.
Hector, Dr. James, F.G.S.
Heller, M. C.
Helmersen, General G. von, F.M.G.S.
Henwood, W. J., Esq., F.G.S.
Holl, Dr. H. B., F.G.S.
Hopkinson, John, Esq.
Humbert, M. A.
Huxley, Prof. T. H., F.G.S.

Jervis, Cav. W., F.G.S.
Jerwood, James, Esq.
Jones, Prof. T. R., F.G.S.
Journal of Travel and Natural History, Editor of the.
Jahrbuch für Mineralogie, Geologie, &c., Editors of the.

Karrer, Dr. F.
Keene, W., Esq., F.G.S.
King, Prof. W.
Kirkby, J., Esq.
Kokscharow, M. N. von, F.C.G.S.

Lapparent, M. de.
Lartet, M. E., F.M.G.S.
Laube, Dr. G. C.
Lea, J., Esq.
Leitner, Dr. G. W.
Leymerie, M. A.
Linnarsson, M. J. G. O.
Logan, Sir W. E., F.G.S.
Login, T., Esq.
London, Edinburgh, and Dublin Philosophical Magazine, Editors of the.
Longman & Co., Messrs.
Lowe, E. J., Esq., F.G.S.
Ludwig, M. R.

Lütken, M. C. F.
Lyell, Sir Charles, Bart., F.G.S.

Mack, M. A.
Mallet, F. R., Esq., F.G.S.
Marsh, Prof. O. C., F.G.S.
Mayer, M. K.
Mechanics' Magazine, Editor of the.
Medical Press and Circular, Editor of the.
Meek, F. B., Esq.
Merian, Dr. P., F.M.G.S.
Miller, Prof. W. H., F.G.S.
Mojsisovics, M. E. von.
Monthly Microscopical Journal, Editor of the.
Morris, Prof. John, F.G.S.

Naturalists' Note Book, Editor of the.
Nature, Editor of.
Newberry, Dr. J. S.
Nielreich, Dr. A.
Nordenskiöld, Prof. A. E., F.C.G.S.

Oldham, Dr. T., F.G.S.

Parker, W. K., Esq.
Peacock, R. A., Esq.
Peters, Dr. Karl F.
Pictet, M. F. J., F.C.G.S.
Pourtales, Count L. de.
Prestwich, Jos., Esq., F.G.S.

Quarterly Journal of Microscopic Science, Editors of the.
Quarterly Journal of Science, Editors of the.
Quetelet, M. A.

Ramsay, A., Esq., jun., F.G.S.
Renevier, M. E.
Reuss, Prof. A. E., F.C.G.S.
Rigaux, M. A.
Revue des Cours Scientifiques, Editors of the.
Richthofen, M. F. von.
Riedl, Dr. M.
Rütimeyer, M. L.

Sarwage, M. E.
Scientific Opinion, Editor of.
Shelford, W., Esq., F.G.S.
Smyth, R. Brough, Esq., F.G.S.
Smyth, W. W., Esq., F.G.S.
Spreafico, M. E.
Steen, M. Adolf.
Student and Intellectual Observer, Editor of the.
Studer, Prof. B.

Tate, G., Esq., F.G.S.
Tate, R., Esq., F.G.S.
Thornton, W. T., Esq.
Trautschold, M. H.
Trutan, M.
Tschermak, M. G.

Waagen, Dr. W.
Walker, Wm., Esq.
Williamson, W. C., Esq.
Wiltshire, Rev. T., F.G.S.
Winchell, Prof. A.

Zirkel, Prof. F., F.C.G.S.

List of PAPERS *read since the last Anniversary Meeting, February* 19*th*, 1869.

1869.

February 24th.—On the British Postglacial Mammalia, by W. Boyd Dawkins, Esq., M.A., F.R.S.

March 10th.—On the Origin of the Northampton Sand, by J. W. Judd, Esq., F.G.S.

———— On the Occurrence of the Remains of *Pterygotus* and *Eurypterus* in the Upper Silurian Rocks in Herefordshire, by the Rev. P. B. Brodie, F.G.S.

March 24th.—On the Cretaceous Strata of England and the North of France, compared with those of the West, South-west, and South of France, and the North of Africa, by Prof. Henri Coquand, of Marseilles; communicated by J. W. Flower, Esq., F.G.S.

———— On the Structure and Affinities of *Sigillaria* and allied Genera, by W. Carruthers, Esq., F.G.S.

———— On the British Species of the Genera *Climacograpsus, Diplograpsus, Dicranograpsus,* and *Didymograpsus,* by H. Alleyne Nicholson, M.B., F.G.S.

April 14th.—On the Coal-mines of Kaianoma, in the Island of Yezo, by F. O. Adams, Esq., Hon. Sec. of Legation in Japan; communicated by the Secretary of State for Foreign Affairs.

———— On a Peculiarity of the Brendon Hills Spathose Iron-ore Veins, by M. Morgans, Esq.; communicated by W. W. Smyth, Esq., F.R.S., F.G.S.

———— On the Salt-mines of St. Domingo, by Dr. F. Ruschhaupt; communicated by Sir R. I. Murchison, Bart., K.C.B., F.R.S., V.P.G.S.

———— A Description of the Broads of East Norfolk, showing their Origin, Position, and Formation in the Valleys of the Rivers Bure, Yare, and Waveney, by R. B. Grantham, Esq., C.E., F.G.S.

———— On a peculiar Instance of Intraglacial Erosion near Norwich, by Searles V. Wood, jun., Esq., F.G.S., and F. W. Harmer, Esq.

1869.

April 14th.—On the Lignite-mines of Podernuovo, near Volterra, by E. J. Beor, Esq., F.G.S.

April 28th.—On the Geology and Mineralogy of Hastings County, Canada West, by T. C. Wallbridge, Esq.; communicated by Dr. Percy, F.R.S., F.G.S.

——— On the Distribution of Flint Implements in the Drift, with reference to some recent Discoveries in Norfolk and Suffolk, by J. W. Flower, Esq., F.G.S.

May 12th.—On some of the Results arising from the Bedding, Joints, and Spheroidal Structure of the Granite of the Eastern Side of Dartmoor, Devonshire, by G. W. Ormerod, Esq., M.A., F.G.S.

——— Notes on Apparent Lithodomous Perforations on the Hills of North-west Lancashire, by D. Mackintosh, Esq., F.G.S.

——— On the Parallel Roads of Glen Roy, by Prof. J. Nicol, F.R.S., F.G.S.

——— On Beds of supposed Rothliegende Age, near Knaresborough, by J. Clifton Ward, Esq., F.G.S.

May 26th.—Notes on the Geology of Cape York Peninsula, Australia, by Alexander Rattray, M.D., R.N.; communicated by the President.

——— On the Formation of the Chesil Bank, Dorset, by H. W. Bristow, Esq., F.R.S., F.G.S., and W. Whitaker, Esq., B.A., F.G.S.

——— On a Raised Beach at Portland Bill, Dorset, by W. Whitaker, Esq., B.A., F.G.S.

——— On the Occurrence of *Terebratula diphya* in the Alps of the Canton de Vaud, by E. B. Tawney, Esq., F.G.S., with a Note by T. Davidson, Esq., F.R.S., F.G.S.

——— on a new Labyrinthodont from Bradford, by T. H. Huxley, LL.D., F.R.S., President; with a Note on its Locality and Stratigraphical Position, by L. C. Miall, Esq.

——— On the Upper Jaw of *Megalosaurus*, by T. H. Huxley, LL.D., F.R.S., President.

June 9th.—Notes on the Sutherland Gold-field, by the Rev. J. M. Joass; with an Introduction by Sir R. I. Murchison, Bart., K.C.B., F.R.S., V.P.G.S.

——— Observations on the "Nuggetty Reef," Mount Tarrangower Gold-field, by Dr. G. H. F. Ulrich, F.G.S.

——— On the Caratal Gold-field, by Dr. C. Le Neve Foster, F.G.S.

——— On the Geology of Guyana, in Venezuela, by Ralph Tate, Esq., F.G.S.

——— On the Nature and Cause of the Glacial Climate, by J. J. Murphy, Esq., F.G.S.

June 23rd.—On two New Species of *Gyrodus*, by Sir Philip de M. G. Egerton, Bart., M.P., F.R.S., V.P.G.S.

——— Note on a very large Saurian Humerus from the Kimmeridge Clay of the Dorset Coast, by J. W. Hulke, Esq., F.R.S., F.G.S.

1869.

June 23rd.—Note on some Fossil Remains of a Gavial-like Saurian from Kimmeridge Bay, establishing its identity with Cuvier's *Deuxième Gavial d'Honfleur, Tête à museau plus court* (*Steneosaurus rostro-minor* of Geoffroy Saint-Hilaire, 1825), and with Quenstedt's *Dakosaurus*, by J. W. Hulke, Esq., F.R.S., F.G.S.

——— On the Geology of a Portion of Abyssinia, by W. T. Blanford, Esq., F.G.S.

——— On the Graphite of the Laurentian of Canada, by Prof. J. W. Dawson, LL.D., F.R.S., F.G.S.

——— On the Correlation, Nature, and Origin of the Drifts of North-west Lancashire and part of Cumberland, by D. Mackintosh, Esq., F.G.S.

——— On the Connexion of the Geological Structure and Physical Features of the South-east of England with the Consumption Death-rate, by W. Whitaker, Esq., B.A., F.G.S.

——— On the Volcanic Phenomena of Hawaii, by the Rev. C. G. Williamson; communicated by Sir R. I. Murchison, Bart., K.C.B., F.R.S., V.P.G.S.

——— Notes on certain of the Intrusive Igneous Rocks of the Lake District, by Dr. H. A. Nicholson, F.G.S.

——— On the Fossil Myriopods of the Coal Formation of Nova Scotia and England, by Samuel H. Scudder, Esq.; communicated by Sir Charles Lyell, Bart., F.R.S., F.G.S.

——— On the Geology of the Country surrounding the Gulf of Cambay, by Alexander Rogers, Esq., F.G.S.

——— On a new Acrodont Saurian from the Lower Chalk, by J. Wood Mason, Esq., F.G.S.

——— On the Rodentia of the Somerset Caves, by W. A. Sanford, Esq., F.G.S.

November 10th.—On Australian Mesozoic Geology and Palæontology, by C. Moore, Esq., F.G.S.

——— On a Plant- and Insect-bed on the Rocky River, New South Wales, by Charles Moore, Esq., F.G.S.

——— On *Hypsilophodon*, a new Genus of Dinosauria, by T. H. Huxley, LL.D., F.R.S., President.

——— Further Evidence of the Affinity between the Dinosaurian Reptiles and Birds, by T. H. Huxley, LL.D., F.R.S., President.

November 24th.—On the Classification of the Dinosauria, with observations on the Dinosauria of the Trias, by T. H. Huxley, LL.D., F.R.S., President.

——— The Physical Geography of Western Europe during the Mesozoic and Cainozoic Periods, elucidated by their Coral Faunas, by P. Martin Duncan, M.B., F.R.S., Sec. G.S.

December 8th.—Notes on the Brachiopoda hitherto obtained from the Pebble-bed at Budleigh Salterton, near Exmouth, in Devonshire, by Thomas Davidson, Esq., F.R.S., F.G.S.

——— On the Relation of the Boulder-clay, without Chalk, of the North of England to the great Chalky Boulder-clay of the South, by Searles V. Wood, jun., Esq., F.G.S.

1869.

December 22nd.—On the Iron-ores associated with the Basalts of the North-east of Ireland, by Ralph Tate, Esq., F.G.S., and J. S. Holden, M.D., F.G.S.

——— Notes on the Structure of *Sigillaria*, by Prof. J. W. Dawson, LL.D., F.R.S., F.G.S.

——— Note on some new Animal Remains from the Carboniferous and Devonian of Canada, by Prof. J. W. Dawson, LL.D., F.R.S., F.G.S.

——— Note on a Crocodilian Skull from Kimmeridge Bay, Dorset, by J. W. Hulke, Esq., F.R.S., F.G.S.

——— Note on some Teeth associated with two fragments of a Jaw from Kimmeridge Bay, by J. W. Hulke, Esq., F.R.S., F.G.S.

1870.

January 12th.—On the Geological Position and Geographical Distribution of the Reptilian or Dolomitic Conglomerate of the Bristol Area, by R. Etheridge, Esq., F.G.S.

——— On the Superficial Deposits of portions of the Avon and Severn Valleys and adjoining Districts, by T. G. B. Lloyd, Esq., C.E., F.G.S.

——— On the Surface Deposits in the neighbourhood of Rugby, by J. M. Wilson, Esq., M.A., F.G.S.

January 26th.—On the Crag of Norfolk and Associated Beds, by Joseph Prestwich, Esq., F.R.S., F.G.S.

February 9th.—On the Fossil Corals (Madreporaria) of the Australian Tertiary Deposits, by P. Martin Duncan, M.B., F.R.S., Sec. G.S.

——— Note on a new and undescribed Wealden Vertebra, by J. W. Hulke, Esq., F.R.S., F.G.S.

——— Note on the Middle Lias in the North-east of Ireland, by Ralph Tate, Esq., F.G.S.

After the Reports had been read, it was resolved,—

That they be received and entered on the Minutes of the Meeting; and that such parts of them as the Council shall think fit be printed and distributed among the Fellows.

It was afterwards resolved,—

That the thanks of the Society be given to Professor Huxley, retiring from the office of President.

That the thanks of the Society be given to Sir R. I. Murchison, Bart., and the Rev. Thomas Wiltshire, retiring from the office of Vice-President.

That the thanks of the Society be given to Professor Rupert Jones, Sir R. I. Murchison, Bart., the Earl of Selkirk, A. Tylor, Esq., and Searles V. Wood, Jun., Esq., retiring from the Council.

After the Balloting-glasses had been duly closed, and the lists examined by the Scrutineers, the following gentlemen were declared to have been duly elected as the Officers and Council for the ensuing year:—

OFFICERS.

PRESIDENT.

Joseph Prestwich, Esq., F.R.S.

VICE-PRESIDENTS.

Sir P. de M. G. Egerton, Bart., M.P., F.R.S.
R. A. C. Godwin-Austen, Esq., F.R.S.
Sir Charles Lyell, Bart., D.C.L., F.R.S.
Warington W. Smyth, Esq., M.A., F.R.S.

SECRETARIES.

P. Martin Duncan, M.B., F.R.S.
John Evans, Esq., F.R.S.

FOREIGN SECRETARY.

Prof. D. T. Ansted, M.A., F.R.S.

TREASURER.

J. Gwyn Jeffreys, Esq., F.R.S.

COUNCIL.

Prof. D. T. Ansted, M.A., F.R.S.
William Carruthers, Esq., F.L.S.
W. Boyd Dawkins, Esq., M.A., F.R.S.
P. Martin Duncan, M.B., F.R.S.
Sir P. de M. G. Egerton, Bart., M.P., F.R.S.
John Evans, Esq., F.R.S., F.S.A.
David Forbes, Esq., F.R.S.
J. Wickham Flower, Esq.
Capt. Douglas Galton, C.B., F.R.S.
R. A. C. Godwin-Austen, Esq., F.R.S.
Harvey B. Holl, M.D.
J. Whitaker Hulke, Esq., F.R.S.
Prof. T. H. Huxley, LL.D., F.R.S.
J. Gwyn Jeffreys, Esq., F.R.S.
Sir Charles Lyell, Bart., D.C.L., F.R.S.
George Maw, Esq., F.L.S.
John Carrick Moore, Esq., M.A., F.R.S.
Prof. John Morris.
Joseph Prestwich, Esq., F.R.S.
Warington W. Smyth, Esq., M.A., F.R.S.
Rev. W. S. Symonds, M.A.
Rev. Thomas Wiltshire, M.A., F.R.A.S.
Henry Woodward, Esq., F.Z.S.

LIST OF

THE FOREIGN MEMBERS

OF THE GEOLOGICAL SOCIETY OF LONDON, IN 1869.

Date of Election.

1819. Count A. Breunner, *Vienna.*
1822. Count Vitaliano Borromeo, *Milan.*
1827. Dr. H. von Dechen, *Bonn.*
1828. M. Léonce Elie de Beaumont, Sec. Perpétuel de l'Instit. France, For. Mem. R.S., *Paris.*
1829. Dr. Ami Boué, *Vienna.*
1829. Dr. J. J. d'Omalius d'Halloy, *Halloy, Belgium.*
1839. Dr. Ch. G. Ehrenberg, For. Mem. R.S., *Berlin.*
1840. Professor Adolphe T. Brongniart, For. Mem. R.S., *Paris.*
1840. Professor Gustav Rose, *Berlin.*
1841. Dr. Louis Agassiz, For. Mem. R.S., *Cambridge, Massachusetts.*
1841. Professor G. P. Deshayes, *Paris.*
1844. William Burton Rogers, Esq., *Boston, U.S.*
1844. M. Edouard de Verneuil, For. Mem. R.S., *Paris.*
1848. James Hall, Esq., *Albany, State of New York.*
1850. Professor Bernard Studer, *Berne.*
1851. Professor James D. Dana, *New Haven, Connecticut.*
1851. General G. von Helmersen, *St. Petersburg.*
1851. Dr. W. K. von Haidinger, For. Mem. R.S., *Vienna.*
1851. Professor Angelo Sismonda, *Turin.*
1853. Count Alexander von Keyserling, *Dorpat.*
1853. Professor L. G. de Koninck, *Liége.*
1854. M. Joachim Barrande, *Prague.*
1854. Professor Carl Friedrich Naumann, *Leipsic.*
1856. Professor Robert W. Bunsen, For. Mem. R.S., *Heidelberg.*
1857. Professor H. R. Goeppert, *Breslau.*
1857. M. E. Lartet, *Paris.*
1857. Professor H. B. Geinitz, *Dresden.*
1857. Dr. Hermann Abich, *Tiflis, Georgia.*
1858. Herr Arn. Escher von der Linth, *Zurich.*
1859. Professor A. Delesse, *Paris.*
1859. Dr. Ferdinand Roemer, *Breslau.*
1860. Dr. H. Milne-Edwards, For. Mem. R.S., *Paris.*
1861. Professor Gustav Bischof, *Bonn.*
1862. Baron Sartorius von Waltershausen, *Göttingen.*
1862. Professor Pierre Merian, *Basle.*

1864. Professor Paolo Savi, *Pisa.*
1865. M. Jules Desnoyers, *Paris.*
1866. Dr. Joseph Leidy, *Philadelphia.*
1867. Professor A. Daubrée, *Paris.*

LIST OF

THE FOREIGN CORRESPONDENTS

OF THE GEOLOGICAL SOCIETY OF LONDON, IN 1869.

Date of Election.

1863. Professor E. Beyrich, *Berlin.*
1863. Herr Bergmeister Credner, *Gotha.*
1863. M. E. Desor, *Neuchâtel.*
1863. Professor Alphonse Favre, *Geneva.*
1863. Signor B. Gastaldi, *Turin.*
1863. M. Paul Gervais, *Montpellier.*
1863. Herr Bergrath Gümbel, *Munich.*
1863. Dr. Franz Ritter von Hauer, *Vienna.*
1863. Professor E. Hébert, *The Sorbonne, Paris.*
1863. Rev. Dr. O. Heer, *Zurich.*
1863. Dr. G. F. Jäger, *Stuttgart.*
1863. Dr. Kaup, *Darmstadt.*
1863. M. Nikolai von Kokscharow, *St. Petersburg.*
1863. M. Lovén, *Stockholm.*
1863. Count A. G. Marschall, *Vienna.*
1863. Professor G. Meneghini, *Pisa.*
1863. M. Henri Nyst, *Brussels.*
1863. Professor F. J. Pictet, *Geneva.*
1863. Signor Ponzi, *Rome.*
1863. Professor Quenstedt, *Tübingen.*
1863. Professor F. Sandberger, *Bavaria.*
1863. Signor Q. Sella, *Turin.*
1863. Dr. F. Senft, *Eisenach.*
1863. Professor E. Suess, *Vienna.*
1863. Marquis de Vibraye, *Paris.*
1864. M. J. Bosquet, *Maestricht.*
1864. Dr. Theodor Kjerulf, *Christiania.*
1864. Dr. Steenstrup, *Copenhagen.*
1864. Dr. Charles Martins, *Montpellier.*
1865. Dr. C. Nilsson, *Stockholm.*
1866. Professor J. P. Lesley, *Philadelphia.*

1866. M. Victor Raulin, *Paris.*
1866. Professor August Emil Reuss, *Vienna.*
1866. Baron Achille de Zigno, *Padua.*
1867. Professor Bernhard Cotta, *Freiburg.*
1868. M. Albert Gaudry, *Paris.*
1869. Professor J. F. Brandt, *St. Petersburg.*
1869. Professor A. E. Nordenskiöld, *Stockholm.*
1869. Professor F. Zirkel, *Kiel.*

AWARDS OF THE WOLLASTON MEDAL

UNDER THE CONDITIONS OF THE "DONATION FUND"

ESTABLISHED BY

WILLIAM HYDE WOLLASTON, M.D., F.R.S., F.G.S., &c.,

"To promote researches concerning the mineral structure of the earth, and to enable the Council of the Geological Society to reward those individuals of any country by whom such researches may hereafter be made,"—"such individual not being a Member of the Council."

1831. Mr. William Smith.
1835. Dr. G. A. Mantell.
1836. M. L. Agassiz.
1837. Capt. P. T. Cautley. Dr. H. Falconer.
1838. Professor R. Owen.
1839. Professor C. G. Ehrenberg.
1840. Professor A. H. Dumont.
1841. M. Adolphe T. Brongniart.
1842. Baron L. von Buch.
1843. M. E. de Beaumont. M. P. A. Dufrénoy.
1845. The Rev. W. D. Conybeare.
1845. Professor John Phillips.
1846. Mr. William Lonsdale.
1847. Dr. Ami Boué.
1848. The Rev. Dr. W. Buckland.
1849. Mr. Joseph Prestwich.
1850. Mr. William Hopkins.
1851. The Rev. Prof. A. Sedgwick.
1852. Dr. W. H. Fitton.
1853. M. le Vicomte A. d'Archiac. M. E. de Verneuil.
1854. Dr. Richard Griffith.
1855. Sir H. T. De la Beche.
1856. Sir W. E. Logan.
1857. M. Joachim Barrande.
1858. Herr Hermann von Meyer. Mr. James Hall.
1859. Mr. Charles Darwin.
1860. Mr. Searles V. Wood.
1861. Professor Dr. H. G. Bronn.
1862. Mr. Robert A. C. Godwin-Austen.
1863. Professor Gustav Bischof.
1864. Sir R. I. Murchison.
1865. Mr. Thomas Davidson.
1866. Sir Charles Lyell.
1867. Mr. G. P. Scrope.
1868. Professor Carl F. Naumann.
1869. Mr. H. C. Sorby.
1870. Professor G. P. Deshayes.

AWARDS

OF THE

BALANCE OF THE PROCEEDS OF THE WOLLASTON "DONATION-FUND."

1831. Mr. William Smith.
1833. Mr. William Lonsdale.
1834. M. Louis Agassiz.
1835. Dr. G. A. Mantell.
1836. M. G. P. Deshayes.
1838. Professor Richard Owen.
1839. Professor C. G. Ehrenberg.
1840. Mr. J. De Carle Sowerby.
1841. Professor Edward Forbes.
1842. Professor John Morris.
1843. Professor John Morris.
1844. Mr. William Lonsdale.
1845. Mr. Geddes Bain.
1846. Mr. William Lonsdale.
1847. M. Alcide d'Orbigny.
1848. Cape of Good Hope Fossils. M. Alcide d'Orbigny.
1849. Mr. William Lonsdale.
1850. Professor John Morris.
1851. M. Joachim Barrande.
1852. Professor John Morris.
1853. M. L. de Koninck.
1854. Mr. S. P. Woodward.
1855. Drs. G. and F. Sandberger.
1856. M. G. P. Deshayes.
1857. Mr. S. P. Woodward.
1858. Mr. James Hall.
1859. Mr. Charles Peach.
1860. Mr. T. Rupert Jones. Mr. W. K. Parker.
1861. Professor A. Daubrée.
1862. Professor Oswald Heer.
1863. Professor Ferdinand Senft.
1864. Professor G. P. Deshayes.
1865. Mr. J. W. Salter.
1866. Mr. Henry Woodward.
1867. Mr. W. H. Baily.
1868. M. J. Bosquet.
1869. Mr. W. Carruthers.
1870. M. Marie Rouault.

Trust-Account.

Receipts.	£	s.	d.	Payments.	£	s.	d.
Balance at Banker's, January 1, 1869, on the Wollaston Donation-fund	31	14	2	Award to Mr. W. Carruthers	21	4	2
Dividends on the Donation-fund for 1869 on Reduced 3 per Cents.	31	15	6	Cost of striking Gold Medal awarded to Mr. H. C. Sorby	10	10	0
				Balance at Banker's, Dec. 31, 1869 (Wollaston-fund) ...	31	15	6
	£63	9	8		£63	9	8

Valuation of the Society's Property; 31*st December*, 1869.

Property.	£	s.	d.	Debts.	£	s.	d.
Due from Longman & Co., on acc. of Journ. Vol. XXV., &c.	50	9	10	Debts incurred previously to 31st December, and now payable	8	2	8
Due from Stanford, on account of Map	11	6	6	Balance in favour of the Society	5930	8	1
Due from Subscribers to Journal (considered good)	25	0	0				
Due for Authors' Corrections in Journal	20	0	0				
Balance in Banker's hands, Dec. 31, 1869	479	15	6				
Balance in Clerk's hands, Dec. 31, 1869	31	0	9				
Funded Property :— Consols, at 95 (£ 5330 s. 14 d. 11)	5064	4	2				
Arrears of Admission-fees (considered good)	56	14	0				
Arrears of Annual Contributions (considered good)	200	0	0				
	£5938	10	9		£5938	10	9

[*N.B. The value of the Collections, Library, Furniture, and stock of unsold Publications is not here included.*]

J. GWYN JEFFREYS, *Treas.*

Feb. 3, 1870.

INCOME EXPECTED.

	£	s.	d.	£	s.	d.
Due for Subscriptions for Quarterly Journal (considered good)	25	0	0			
Due for Authors' Corrections	20	0	0			
Due for Arrears (See Valuation-sheet)	256	14	0			
				301	14	0
Estimated Ordinary Income for 1870.						
Annual Contributions :—						
From Resident Fellows, and Non-residents of 1859 to 1861				800	0	0
Admission-fees (supposed)				250	0	0
Compositions (supposed)				250	0	0
Dividends on Consols				156	11	10
Sale of Transactions, Proceedings, Library-catalogues, and Ormerod's Index	10	0	0			
Sale of Quarterly Journal	220	0	0			
Sale of Geological Map	25	0	0			
				255	0	0
Due from Longman and Co. in June	50	9	10			
Due from Stanford and Co. in June	11	6	6			
				61	16	4
				£2075	2	2

J. GWYN JEFFREYS, TREAS.

Feb. 3, 1870.

EXPENDITURE ESTIMATED.

	£	s.	d.	£	s.	d.
General Expenditure:						
Taxes and Insurance	60	0	0			
Furniture	15	0	0			
House-repairs	25	0	0			
Fuel	30	0	0			
Light	30	0	0			
Miscellaneous House-expenses	65	0	0			
Stationery	35	0	0			
Miscellaneous Printing, including Abstracts	75	0	0			
Tea for Meetings	25	0	0			
				360	0	0
Salaries and Wages:						
Assistant Secretary	210	0	0			
Clerk	100	0	0			
Assistant in Library and Museum	65	0	0			
Porter	100	0	0			
Housemaid	40	0	0			
Occasional Attendants	10	0	0			
Collector	20	0	0			
Accountant	5	0	0			
				550	0	0
Library	100	0	0			
Museum	5	0	0			
				105	0	0
Miscellaneous Scientific Expenditure				60	0	0
Diagrams at Meetings				20	0	0
Publications: Quarterly Journals	650	0	0			
,, Geological Map	20	0	0			
,, Ormerod's Index	110	0	0			
				780	0	0
Balance in favour of the Society				200	2	2
				£2075	2	2

RECEIPTS.

	£	s.	d.	£	s.	d.
Balance at Banker's January 1, 1869	376	13	5			
Balance in Clerk's hands	35	7	1			
				412	0	6
Compositions received				252	0	0
Arrears of Admission-fees	50	8	0			
Admission-fees, 1869	277	4	0			
				327	12	0
Arrears of Annual Contributions				177	19	6
Annual Contributions for 1869, viz. :—						
Resident Fellows £742 7 0						
Non-Resident Fellows ... 38 2 0						
				780	9	0
Annual Contributions in advance.................				11	12	0
Dividends on Consols				149	19	7
Journal Subscriptions in advance				1	5	0
Publications :						
Sale of Transactions	1	1	0			
Sale of Journal, Vols. 1–24	101	12	0			
,, Vol. 25*	133	17	0			
Sale of Geological Map	26	0	4			
Sale of Library-catalogues	2	13	0			
Sale of President's Address................	0	11	0			
				265	14	4
				£2378	11	11

We have compared the Books and Accounts presented to us with this statement, and find them agree.

(Signed) ALFRED TYLOR, J. LOGAN LOBLEY, } *Auditors.*

Feb. 3, 1870.

	£	s.	d.
* Due from Messrs. Longman, in addition to the above, on Journal, Vol. 25, &c.	50	9	10
Due from Fellows for Journal subscriptions, estimated	25	0	0
Due from Messrs. Stanford on Geological Map	11	6	6
	£86	16	4

Year ending December 31*st*, 1869.

EXPENDITURE.

	£	s.	d.	£	s.	d.
General Expenditure:						
Taxes	35	10	2			
Fire-insurance	9	0	0			
New Furniture	15	9	7			
House-repairs	14	15	10			
Fuel	29	17	0			
Light	29	15	6			
Miscellaneous House-expenses	75	14	9			
Stationery	15	18	3			
Miscellaneous Printing, including Abstracts	63	17	6			
Tea at Meetings	20	7	2			
				310	5	9
Salaries and Wages:						
Assistant-Secretary	200	0	0			
Clerk	100	0	0			
Library and Museum Assistants	77	0	0			
Porter	100	0	0			
Housemaid	40	0	0			
Occasional attendants	8	0	0			
Collector	18	14	9			
Accountant	5	0	0			
				548	14	9
Library				101	6	8
Museum				3	16	6
Miscellaneous Scientific Expenses				49	2	7
Diagrams at Meetings				1	6	0
Investment in £214 3*s*. 10*d*. Consols				200	0	0
Publications:						
Geological Map	48	0	9			
Journal, Vols. 1–24	41	6	2			
„ Vol. 25	556	3	10			
Ormerod's Index	7	12	8			
				653	3	5
Balance at Banker's, Dec. 31, 1869	479	15	6			
Balance in Clerk's hands, Dec. 31, 1869	31	0	9			
				510	16	3
				£2378	11	11

AUDITORS' REPORT.

The Auditors for 1869 draw the attention of the Council to the increase of the arrears of Annual Contributions from year to year. Many names appear on the list of Members which should be removed, as all attempts to collect the overdue amounts have been ineffectual.

The Auditors would recommend that the names of all the Fellows owing for 4 years and more, should be either removed from the list of Fellows, or proceedings taken against them. At the present time the number of these Fellows is 27.

The alteration in the mode of keeping the books by shortening the entries under Coutts' and Accountant's accounts, suggested by the Clerk and approved by the Accountant, is an improvement in the opinion of the Auditors.

The books are very neatly and well kept.

ALFRED TYLOR.
J. LOGAN LOBLEY.

Feb. 3, 1870.

PROCEEDINGS

AT THE

ANNUAL GENERAL MEETING,

18TH FEBRUARY, 1870.

AWARD OF THE WOLLASTON MEDAL.

THE Reports of the Council and of the Committees and Auditors having been read, the President, Professor HUXLEY, LL.D., F.R.S., handed the Wollaston Gold Medal to JOHN EVANS, Esq., F.R.S., for transmission to M. G. P. DESHAYES, addressing him as follows:—

I request you to transmit the Wollaston Medal for this year to M. Deshayes as an expression on the part of the Geological Society of the high estimation in which his services to Palæontology and Geology, especially in regard to the classification of the Tertiary formation, are held by the geologists of this country.

Six years ago the Council of this Society demonstrated the interest which it took in M. Deshayes's valuable investigations by awarding him the Donation-fund. Now that those researches, commenced just fifty years ago, are completed, and the labours of a life devoted to science are crowned by the publication of five great volumes containing descriptions and figures of all the Mollusca of the Paris basin, it has seemed to the Council a fitting opportunity for bestowing the highest honour at its disposal upon the pupil, editor, and continuator of Lamarck, and the worthy successor of his great master in the Chair of Natural History in the Muséum d'Histoire Naturelle.

Mr. EVANS read the following reply on behalf of Prof. ANSTED, F.R.S., the Foreign Secretary of the Society, who was unavoidably absent:—

I have the honour to acknowledge, on the part of M. Deshayes, the award of the Wollaston Medal; and in forwarding to him this mark of the estimation in which his labours are held among English geologists, I will not fail to communicate the observations you, Sir, as representing the Society, have thought fit to express.

It is much to be regretted that M. Deshayes is not present in person to receive this Medal, and assure you of the extent to which he appreciates it. On three occasions, the first no less than thirty-four years ago, he received the award of the proceeds of the Wollaston Donation-fund to assist him in those long-continued researches of which we have lately received the completion, in the publication of the last volume of the work with which his name will always be connected. Placed in a district rich in an extraordinary degree in fossils of one geological period, he has devoted himself to the study

of one important group of these fossils; and how well he has succeeded his recent appointment to the Chair of Lamarck in France and the award of the Wollaston Medal in England afford sufficient illustration.

In a letter from M. Deshayes he has expressed to me his sense of the honour conferred upon him as follows:—

Monsieur et très-honoré Collègue,

J'ai reçu avec un extrême plaisir la lettre par laquelle vous m'annoncez officiellement la décision prise par le Conseil de la Société Géologique de Londres, de m'accorder pour cette année la Médaille d'or de Wollaston.

J'ai l'honneur de vous prier d'être près du conseil l'interprète des sentiments de gratitude dont mon cœur est rempli. La noble récompense dont je suis honoré, est la seule que j'eusse ambitionnée; elle m'arrive dans ma vieillesse; elle est pour moi le couronnement de ma vie scientifique, commencée il y a juste cinquante ans. Je suis heureux et fier de voir mes travaux approuvés par les hommes les plus compétents du monde.

J'aurais voulu me rendre à Londres à la réunion générale de la Société; j'ai eu dans ma vie, une fois, la bonne fortune d'y assister, et j'avoue que j'en ai conservé le souvenir le plus agréable et le plus précieux; assis près de mes amis Murchison, Forbes, et Labèche, puis-je perdre de tels souvenirs se rattachant a de tels hommes! Cette année malheureusement il me sera impossible de me rendre à Londres; mon âge, ma santé, les occupations que me donnent mes fonctions au Muséum, sont des obstacles que je ne puis surmonter. J'en éprouve un regret d'autant plus vif, que j'aurais trouvés réunis mes anciens amis ainsi que d'autres personnes dont j'aurais été heureux de le devenir en faisant leur connaissance. Parmi ces personnes, Monsieur et cher collègue, vous tenez une place considerable.

Veuillez recevoir l'assurance de la parfaite considération avec laquelle j'ai l'honneur de vous saluer.

Deshayes.

Award of the Wollaston Donation-fund.

The President then presented the Balance of the proceeds of the Wollaston Donation-fund to John Evans, Esq., F.R.S., for transmission to M. Marie Rouault, Keeper of the Geological Museum at Rennes, and addressed him as follows:—

The cosmopolitanism of science is well illustrated by the fact that all the honours at our disposal this year are gladly and willingly accorded to foreigners. The Wollaston Medal has gone to M. Deshayes. The fund has been awarded by the Council to another member of the same great nationality, M. Marie Rouault, who, working under difficulties and discouragements such as those which

beset the early life of our own Hugh Miller, has made most important contributions to our knowledge of the fauna of the oldest palæozoic rocks of France.

Mr. Evans read the following acknowledgment on behalf of Prof. Ansted:—

In returning thanks on the part of Monsieur Rouault for the grant of the balance of the proceeds of the Wollaston-fund, I will take the opportunity of saying a few words concerning the nature and extent of the scientific work executed by this hardy and persevering geologist in his own most difficult country.

Monsieur Rouault is one of those men who are independent of and rise above all distinctions of class. Self-educated in the strictest sense of the term, a collector of fossils because his nature would not allow him to be other, he resembles the lamented Hugh Miller and our still active and useful countryman Mr. Peach, the latter of whom attained a similar distinction under very similar difficulties.

Nearly seventeen years ago the valuable collections already in the possession of Monsieur Rouault were presented to the municipality of Rennes, and formed the principal nucleus of a museum then first established. The previous owner then became *Directeur-conservateur* of the Geological and Palæontological Museum of the town of Rennes; and this museum has since its first establishment been greatly enriched by the same agency. It is exceedingly rich in local fossils, and contains many type specimens, some of extreme interest.

The money I receive on the part of M. Rouault will, I am sure, be employed by him in the best interests of science, and will be recognized as a fit acknowledgment of the services he has already rendered to palæozoic geology, and an earnest of work still in progress.

THE ANNIVERSARY ADDRESS OF THE PRESIDENT,

Professor Huxley, LL.D., F.R.S.

Among the numerous Fellows and Foreign Members of the Society whose loss during the past year we have to regret, I may refer particularly to the following:—

Etienne Jules Adolphe Dexmier de Simon, Vicomte d'Archiac, was born at Reims on the 24th of September, 1802. On the completion of his education, at the Military School of St. Cyr, he entered the army, and remained a cavalry officer until the revolution of July 1830, when he quitted the service. During M. d'Archiac's nine years of military life, his great capacity for the successful cultivation of natural science appears to have lain dormant. At least, the only recorded products of his pen during that time are, a historical novel in three volumes, and a political pamphlet.

It is not until 1835 that the long series of writings which raised

D'Archiac to the position in the front rank of European geologists, which he occupied at the time of his death, commenced, by the publication of a 'Résumé d'un Mémoire sur le terrain tertiare du département de l'Aisne.' This inaugural essay was followed, in 1838 and 1839, by others upon the tertiary and cretaceous deposits of France, Belgium, and England. Of these, the 'Observations sur le groupe moyen de la Formation Crétacée' requires particular notice, as a piece of thorough palæontological and geological work, undertaken not for the mere purpose of determining the geology of the district, but with the more important object of ascertaining whether a properly chosen district might not be made to contribute to the solution of a problem in general geology. This problem is thus formulated by d'Archiac, "How are the fossils of a formation distributed in the different stages of that formation? And what modifications or changes do the species undergo, on the one hand, in time, as we pass from one stage to another, and, on the other, in space, as we examine the formation at different points of its geographical extent?"

In order to solve the problem thus stated, M. d'Archiac observes that it is necessary to select a formation which can be studied upon its circumference, and at a great number of intermediate points, which has not undergone any serious dislocation, and all the stages of which present definite marks by which they can be compared.

The Cretaceous formation, stretching from Burgundy to Dorsetshire, appearing to fulfil these conditions, was therefore subjected to a minute and exhaustive study, and it yielded the following replies to the questions proposed:—The more the different stages of a formation are developed, the more distinct are the organisms which they contain, or, in other words, the smaller is the number of species common to any two of them. Further, as the number of the members of the same formation diminishes, on the one hand, the species of the different stages tend to become mixed together; and, on the other, new species, and even new genera, appear in inverse proportion to the number of the stages which persist. Thus the fossils at the margins of the Middle Cretaceous formation differ from those of its centre, and, moreover, they differ geographically. The cretaceous organisms inhabit three zones, a northern, a middle, and a southern, and these have a general direction from N.W. to S.E., which probably corresponds with that of the isothermal lines of the period.

The sixth volume of the 'Transactions' of our Society is adorned by a very elaborate memoir "On the Fossils of the older Deposits in the Rhenish Provinces," in which, in conjunction with our distinguished foreign member M. de Verneuil, M. d'Archiac subjects a great section of palæozoic life to a similar investigation, and conclusions of no less importance are there stated:—"If the development of palæozoic organisms be considered relatively to the thickness of the beds, or the duration of the epoch, we shall see, 1st, *that the total number of species always increases from below upwards*; 2nd, *that the progression is very different in each order and in each family, and that this progression is even frequently inverse, either in*

the different orders of the same class, or in the various genera of the same order. If, on the other hand, the development of the palæozoic creation be considered relatively to its horizontal extent, or geographically in relation *to space,* it will be seen, 1st, *that the species which are found in a great number of localities, and in very distant countries, are almost always those which have lived during the formation of several successive systems*; 2nd, *that the species which belong to a single system are rarely observed at great distances, and that they then constitute local faunæ, peculiar to certain countries; whence it results that the species really characteristic of a system of beds are so much the less numerous as the system is studied upon a vaster scale.*" It must be remembered that these most important generalizations were communicated to this Society in the year 1841, and though the able authors of the memoir express their satisfaction at finding their conclusions in accordance with those independently arrived at by Prof. Phillips, I am not sure that either their substance, or their origin, is even now quite so familiar to palæontologists as it ought to be.

From 1842 to 1847, M. d'Archiac was occupied with the investigation of the Cretaceous and Tertiary deposits of France and Belgium, and published several valuable works, among which I may mention the 'Description Géologique du Département de l'Aisne' (1843), and the 'Description des fossiles des couches nummulitiques des environs de Bayonne' (1846 and 1850). The line of inquiry opened up by the last-mentioned works could not fail to be attractive to so philosophical a geologist and biologist; but few men are blessed with the prodigious industry which enabled D'Archiac to produce, in seven years, not only these memoirs, but the major part of the great monograph on the Nummulitic formation of India, which was published in 1853; while at the same time he was occupied with such a work as the 'Histoire des progrés de la Géologie de 1834 à 1845,' five volumes of which appeared between 1847 and 1853. I have had the curiosity to put together the total number of pages of these five volumes, and I find that, for this work only, D'Archiac must have written, on the average, the matter which fills 600 closely printed octavo pages every year for six years. And when we consider that this matter consists of a fair and faithful critical digest of innumerable books and memoirs, all which must needs have been read, and that it contains a great amount of original thought, one's respect for its author's power of work rises almost into awe.

The eighth volume of this extremely valuable work was published in 1860, and it is profoundly to be regretted that it remains incomplete. The author's plan is to deal with the history of each formation in successive order, from the youngest to the oldest, starting with the year 1834, and carrying his history, in the early volume, as far as 1845, in the later volumes to a more recent date. The last volume deals with the history of Triassic geology from 1834 to 1859.

In 1857 M. d'Archiac was elected a member of the Academy of Sciences, in the place of M. Constant Prévost; and, on the death of

Alcide d'Orbigny, in 1861, he was nominated to fill the chair of palæontology in the Muséum d'Histoire Naturelle in Paris.

The substance of four of the courses of lectures which M. d'Archiac delivered in his new capacity has been published in three volumes, under the title of 'Cours de Paléontologie Stratigraphique.' The first volume contains a précis of the history of palæontology; the second is devoted to a general view of biology, as an introduction to palæontology; while the third gives an account of the fauna of the Quaternary epoch. At this point the series of the 'Cours de Paléontologie' ceases; but, in 1866, a complete treatise, embodying M. d'Archiac's views on the totality of geological phenomena, entitled 'Géologie et Paléontologie' appeared.

The last work from M. d'Archiac's pen is the great Report on the Palæontology of France, which was published in 1868.

All who have known M. d'Archiac personally, speak in the warmest terms of the uprightness of his character, and of his keen sense of honour and independence. And it is lamentable to know that the pressure of petty cares so destroyed the balance of his sensitive and finely strung mind, that a few more years of patient endurance of such troubles appeared as little possible to him as any application for help to the many friends who were not only able, but would have been proud to serve him. The Vicomte d'Archiac was in his sixty-seventh year at the time of his death.

Joseph Beete Jukes, Fellow of the Royal Society, was born in Birmingham on the 18th of October 1811, and was educated partly at the Merchant Taylor's School in Wolverhampton, and partly at King Edward's School in Birmingham. At the latter school he gained an exhibition, which took him to Cambridge, where he entered St. John's College in 1830, and took his B.A. degree in 1836, proceeding to his M.A. in 1841.

The genial enthusiasm and large knowledge of the Woodwardian Professor of Geology, then in his vigorous prime, worked upon Mr. Jukes, as they seem to have affected all men who came within the range of their influence, and determined him to make geological investigation the vocation of his life. Immediately after leaving Cambridge Mr. Jukes became a Fellow of this Society, and, as we all know, he was for four and twenty years one of its most active and valued members.

In 1839 Mr. Jukes was appointed to the office of Geological Surveyor of Newfoundland. He remained for two years in this capacity, and executed the survey as well as the means at his disposal would permit. When, however, the work was done, the capricious parsimony of the Colonial Legislature refused to grant the money requisite to pay for the 'Report,' and it would have been lost to science if the Governor, Sir John Harvey, whose name ought to be gratefully recollected by geologists, had not taken the expense upon himself. The "Report," forms a part of the 'Excursions in Newfoundland,' published in 1842. In the latter year appeared Potter's 'History of Charnwood Forest,' which contains an able and inter-

esting essay on the geology of that district, written by Mr. Jukes after his return from Newfoundland.

In the preface to the 'Excursions in Newfoundland' the author excuses the imperfection of the work on the ground that he is again leaving England. In fact, in June 1842 H.M.S. 'Fly' was despatched, under the command of the late Capt. Blackwood, to survey the Barrier-reef upon the east coast of Australia, and Mr. Jukes was appointed naturalist to the ship, which did not return to England till 1846. In 1847 Mr. Jukes published his 'Narrative of the Surveying Voyage of H.M.S. 'Fly,'' in two volumes.

The 'Narrative' is well written, and gives a very vivid and accurate account of the places and people visited, if I may judge from what is said of those parts of the ground over which it was my fortune to travel a few years later. The naturalist, the geologist, and the ethnologist will find much valuable information in these volumes; and, to the student of geographical distribution, especial interest attaches to Mr. Jukes's suggestion that the different character of the molluscan faunæ of the north and south shores of Torres Straits is the result of the formation of these straits by the depression which gave rise to the formation of the Barrier reef; while the similar elements in the land faunæ of Australia and New Guinea arise from the direct connexion of these two masses of land in the time which preceded the formation of Torres Straits.

Shortly after his return to England, in 1846, Mr. Jukes received an appointment to the Geological Survey of Great Britain, then under the direction of the late Sir Henry de la Beche. He was despatched to North Wales (where Prof. Ramsay was directing the operations of the Survey), and did excellent work in mapping the district about Bala and Conway during the summers of several years, while the winters were employed in surveying the Coal-measures of his native county.

The results of the latter work appeared among the publications of the Survey in 1853, as a 'Memoir on the Geology of the South-Staffordshire Coal-fields,' which is of very great importance, alike in its scientific and in its practical bearings. So strongly was its value in the latter direction felt by the public, that the first edition of the memoir was exhausted in a few years, and of a second revised and enlarged edition, which was published in 1858, not a copy now remains.

In 1850 Mr. Jukes was appointed Local Director of the Irish branch of the Survey, in room of Prof. Oldham, who had undertaken the direction of the Geological Survey of India. In this capacity Mr. Jukes laboured for nineteen years, with unremitting energy, and the most conscientious desire to do his duty, in a position which was full of difficulties, and involved much wear and tear of both mind and body. During this period, he edited and largely contributed to no fewer than forty-two memoirs explanatory of the geological maps of the southern, eastern, and western parts of Ireland, executed by the Survey.

In addition to these labours Mr. Jukes for many years discharged

the functions of a Professor of Geology, first in connexion with the Royal Dublin Society and Museum of Irish Industry, and afterwards in the Royal College of Science in Dublin. He wrote a very good elementary manual of geology, and some school-books upon geology and physical geography; and he read a large number of papers and notices before this society and the Geological Society of Dublin, of which last body he was President during the years 1853 and 1854. Several of these papers, such as that "On the mode of formation of some of the river-valleys of the South of Ireland," show how completely Mr. Jukes shared with his colleagues, Prof. Ramsay and others, that tendency to return to Huttonian methods of accounting for the form of terrestrial surfaces which is so marked a feature of a rising and active school of geologists.

The Fellows of this Society have, doubtless, a clear recollection of the discussions to which two of Mr. Jukes's papers, that "On the mode of formation of river-valleys of the South of Ireland," to which I have just referred, and that "Upon the Carboniferous slates and Devonian rocks and the Old Red Sandstone of the South of Ireland," gave rise. They will have a vivid remembrance of the heartiness and vigour with which our colleague threw himself into the defence of his favourite views; and I am sure they will no less distinctly bear in mind the inexhaustible fund of good humour with which he bore the onslaughts of his opponents.

It was my privilege to count Mr. Jukes among my oldest and most familiar friends. He had an eminently transparent character, and I can honestly say that, after nearly twenty years' intercourse, my mental picture of him remains as it at first impressed itself, that of an upright, generous man, of considerable scientific powers, of great energy, of good administrative capacity, and of the most entire honesty of purpose. If his openness and generosity occasionally led him into what, in his official position, was imprudence in his dealings with men, and if his energy sometimes took what his friends thought a wrong direction, no one could better bear being told of his faults, or be less resentful of good counsel.

Mr. Jukes had a remarkably fine and robust-looking bodily frame; but his health broke down in 1866, and though he rallied and became almost himself again, his disease made progress, and after being disabled for nine months, he died on the 1st of August, 1869.

The life of Hermann Christian Erich von Meyer, who was born at Frankfort on the Maine on the 3rd September 1801, is that of a retired student, and as such devoid of incident, though few men will leave a deeper mark upon the records of palæontology. He himself, in the preface to his 'Essay on fossil teeth and bones of Georgensgmünd,' written in 1834, tells us how he was led to the study of fossils:—

"When many years ago I began this investigation, I little thought of the difficulties which awaited me. Love of the work has helped me to overcome them, though they made themselves severely felt as I went on. I was familiar only with chemistry and mineralogy,

and to a certain extent with geology. Comparative anatomy and osteology were an altogether unknown region; but I found myself drawn into it by the remains of a long-extinct fauna. And the first impulse was given by the discovery of a perfect fossil skull of an ox, with a wound in the frontal bone; this led to my busying myself with other fossil bones, and even to the discovery of some. The attempts to determine their nature are contained in my "Beiträge zur Petrefaktenkunde," which extend through several volumes of the 'Acta' of the Leopoldino-Caroline Academy."

The first portion of the "Beiträge," to which Von Meyer here alludes, is published in the 'Nova Acta' for 1829, in that fiftieth volume which contains Goethe's famous essay on the intermaxillary bone; and it includes four essays which offer a good example of the extent and variety of Von Meyer's knowledge, even at that time. The first is upon an Orthoceratite, the second upon *Mastodon arvernensis*, the third on *Aptychus*, the fourth on two new fossil reptiles, *Rhacheosaurus* and *Pleurosaurus*. For thirty years Von Meyer poured forth a continuous torrent of excellent and richly illustrated memoirs, sometimes upon *Mollusca*, sometimes on *Crustacea*, sometimes upon Fishes, but most commonly upon Reptiles and *Mammalia*.

The most complete monograph extant on the *Amphibia* of the Carboniferous epoch is by Von Meyer; the only monograph upon the Permian *Reptilia* is also from his pen. The great work upon the Fauna of the Muschelkalk, which was published in 1847–1852, is a wonderful monument of patient and skilful labour, and when it appeared, effected a revolution in the minds of geologists as to the character of the Triassic fauna, which instead of being poverty-stricken, as some supposed, revealed about eighty species of Labyrinthodonts and Reptiles in Germany alone. This fine monograph was supplemented by several excellent memoirs on the Triassic Fauna in the 'Palæontographica.' No less valuable is the work upon the Fauna of the Lithographic slates, which affords a complete conspectus of the Reptiles of that rich deposit.

In the preface to the memoir on the fossils of Georgensgmünd, to which I have already referred, Von Meyer makes some excellent remarks on the value of drawing as a help to the palæontologist, and on the frequent imperfections of drawings of fossils, and especially of osteological subjects, which are not made by persons conversant with anatomy. "I knew all this well enough," says he, "but I had no practice with the pencil, nor any experience in managing light and shade." This was a difficulty which would have appalled most men, but not Von Meyer, who set to work to teach himself drawing; with what admirable success all who are familiar with his works know. For it was Von Meyer's practice to draw all the illustrations of his numerous memoirs on the stone; and, at a rough estimate, some hundreds of quarto and folio plates must have proceeded from his swift and accurate pencil. There are seventy folio plates in the 'Saurier des Muschelkalkes' alone.

Though he must have devoted an immense amount of time and

labour to the mere details of palæontological work, it would be a great mistake to count Von Meyer among the mere men of detail. On the contrary, his 'Palæologica,' published in 1832, is full of instructive and original thought, especially the second essay of the three comprised in the work. Von Meyer strongly insists upon the importance of the fact that fossil forms so often fill up the gaps in the series of existing forms, and exhibit in combination characteristics found at present only in distinct groups. Hence, he justly remarks, it results that "conclusions drawn from one part of the skeleton to the structure of the entire animal have turned out to be erroneous, and that even anatomists like Camper have been deceived" (*l. c.* p. 197): and in his later works this eminent palæontologist constantly repeats this much-needed warning against the current exaggerations of Cuvier's unguarded phrases.

Von Meyer died on the 2nd of April, 1869.

John William Salter, A.L.S., F.G.S., born December 15th, 1820, died December 2nd, 1869. This eminent palæontologist, after an education at a private boarding-school, was, in April 1835, by his own wish, bound apprentice to the well-known James De Carle Sowerby, with whom he hoped to pursue the study of Natural History (especially Entomology) for which he had, from childhood, an ardent love. He has been known to pull his companions (Wm. and J. Sowerby) out of bed on a cold winter's morning to wade through the snow after some insect the habitat of which he had just heard of; or, at other times, knee-deep in the long hay-grass to a favourite pond after water-insects. About this time (1836–37) he wrote his first paper "On the Habits of Insects," read at the Camden Literary Society.

With Mr. Sowerby he was engaged in drawing and engraving the plates of 'Sowerby's Mineral Conchology' then in progress towards completion, of the 'Supplement to Sowerby's English Botany,' of 'Loudon's Encyclopædia of Plants,' and 'Murchison's Silurian System.' The figures for these and many other scientific works, engraved by Mr. Salter at this time, being all drawn from the actual specimens, he was, naturally, training his eye to that perfect knowledge of fossil forms which in later years rendered him so distinguished and keen a palæontologist.

In 1842 he visited Cambridge, where he remained for a short time to assist Professor Sedgwick in arranging the fossils of the Woodwardian Museum. It is not uninteresting here to note that the first and the last independent work of his life was at the Cambridge Museum in connexion with Sedgwick, who continued to be to Salter, up to the last, what, indeed, he has been to so many others, a staunch and generous friend.

In that and the three following years he made several short trips into Wales, and did his first field-geology under Sedgwick's teaching, whom he always referred to as "the Master."

In 1846 he married Sally, second daughter of Mr. J. De Carle Sowerby, with whom he had learnt that art of which, in the illustra-

tions to so many scientific works, he has left testimony showing not only the ability of the master but the aptitude of the pupil.

In the same year, at the age of 26, he entered upon the Geological Survey, and for eight years served as chief assistant to the palæontologist, Prof. Edward Forbes. Writing to his friend Dr. Grindrod, of Malvern, Salter says*, "From 1846 to the time of Forbes's removal to Edinburgh in 1854, I shared with him the arrangement, description, and cataloguing of the public fossil collections of the Survey, took part in the field-work, and in all other duties shared the work with him and had his full approval."

On the retirement of Edward Forbes it was found expedient to separate the Lectureship on Natural History from the office of Palæontologist. Prof. Huxley was accordingly appointed to the former post, that of Naturalist to the Geological Survey, while Mr. Salter was installed in the latter office.

In consequence of the increasing extent of the labours of the Geological Surveyors, the examination of the Irish fossils was, in 1856, handed over to Mr. W. Hellier Baily, and in the following year Mr. Robert Etheridge, having been appointed Assistant Naturalist to the Geological Survey, took charge of the fossils of the Secondary and Tertiary formations of Britain, thus leaving Mr. Salter free to devote his whole energies to his favourite work—the fossils of the palæozoic formations.

During his period of office Mr. Salter prepared three Decades, with 10 plates each (8vo size), on the Trilobites in the collection at Jermyn Street, and, in conjunction with Prof. Huxley, a Monograph on the genus *Pterygotus*, illustrated with sixteen folio plates. He also completed a Decade on the *Echini*, commenced by Prof. Forbes, and supplied a part of the palæontology to Prof. Phillips's 'Memoir on Malvern.'

The palæontological portion of Prof. Ramsay's 'Memoirs on North Wales' was also written by Mr. Salter.

The officer holding the position of Palæontologist to the Geological Survey of Great Britain has a large amount of routine work in examining and naming specimens and preparing lists of fossils of most prodigious length for the purposes of the Survey, and for exhibition in the Museum; and, added to all this, a series of demonstrations have to be given annually to the students of the School of Mines, on fossils characteristic of the various strata, with their range and distribution in time and space.

More than thirty papers by Mr. Salter, on various geological topics, are to be found in the Journal of the Geological Society; he also wrote in the 'Annals and Magazine of Natural History,' the 'Geological Magazine,' &c.

Four parts of a Memoir on British Trilobites, illustrated by thirty

* The letter we refer to is dated "Leicester House, Malvern, Nov. 14, 1868," and is addressed to Dr. Grindrod and W. Mathews, Esq., M.A., F.G.S., and appears to have been intended for publication, with a view to soliciting a pension from Government, which, owing to his retiring at the end of 17 years' service (in 1863), he was not entitled to claim.

4to plates, and 216 pages of text, have been published by the Palæontographical Society.

In Murchison's 'Siluria,' and Lyell's 'Manual,' Mr. Salter's services, with both pen or pencil, are apparent and acknowledged. Mr. Salter has also contributed to Sedgwick's Memoirs, 1844–47, Sharpe's Memoirs (Geol. Proceedings), and the Reports of the British Association, 1844–68 (Sections).

In the published account of the Arctic voyages of Beechey, Ommaney, and Penny, the description and correlation of the fossils was made by him. Mr. Salter has described fossils from the Himalayas, Australia, China, South Africa, Canada, Oregon, &c. &c.

A list of sixty separate papers by Mr. Salter is given in Bigsby's 'Thesaurus Siluricus,' in the preparation of which he was also engaged.

He projected and, conjointly with Mr. Henry Woodward, prepared a Tabular view of British Fossil Crustacea, showing their range in time, which was engraved and published by Mr. J. W. Lowry, in 1865, and, but for the great expense attending the engraving, several other groups were also intended to be tabulated.

In 1865, Mr. Salter received the "Wollaston Donation-fund" from the Geological Society, in recognition of his valuable services to palæontology, and especially for his Monograph on Trilobites, then in course of publicatien by the Palæontographical Society.

After his retirement from the office of Palæontologist to the Geological Survey in 1863, he was engaged at various times in arranging and naming the Palæozoic Invertebrata of the Manchester, Leicester, Leeds, Worcester, Malvern, Taunton, and Cambridge Museum collections; he also executed numerous plates and woodcuts. A catalogue (illustrated by himself) of the Cambrian and Silurian fossils in the Woodwardian Museum was one of the last tasks which he undertook; it remains uncompleted, as does his Monograph on the Trilobites.

It is difficult to say what combination of official conditions could have been found better suited to him than those in which he was placed. He often pictured the happiness of a post in the British Museum; but it is doubtful, had he realized his hope, whether his health would have improved. Those who knew him well will remember how cheerful and light-hearted he was at times; he was, in many ways, remarkably like a child, fond of boyish athletic sports, a lover of Nature, fond of wild flowers and domestic pet animals, which he encouraged his children to keep. Anon he would be fretful and irritable, often without any reasonable cause, proving that the chronic ill-health of which he complained was certainly mental.

His staunch friends, Murchison and Sedgwick, helped him right manfully throughout, and he had many friends in the West of England and of Scotland, who gladly welcomed him to their homes and cordially sympathized with him. But though he spoke cheerfully and hopefully after resigning his post at Jermyn Street, there is no doubt that he regretted the step he had taken.

No one, however, who will fairly weigh the amount of valuable work done by Mr. Salter, and the large contributions he has made to our knowledge of the palæozoic rocks and the early life-forms which they contain, will deny that a man of such ability deserved some recognition in the way of pension from Government; and it is sincerely to be hoped that Mrs. Salter, with her seven children, may at least be granted some small share of the Royal bounty, as some acknowledgment of the services rendered to science by her husband.

Mr. Salter is buried in Highgate Cemetery, the resting-place of several of his fellow-workers in science.

Richard Nathaniel Rubidge, M.B. Lond., who was well known as an enthusiastic labourer in the geology of South Africa, died suddenly, at Port Elizabeth, on the 8th of August, 1869. Beginning his medical studies under Dr. John Atherstone, of Port Elizabeth, his habit of accurate observation was acquired and fostered in company with his fellow pupil and friend, Dr. W. G. Atherstone, of that town, also known as an ardent and successful geological explorer of South Africa, some time in company with the late Mr. A. G. Bain, who first worked out and mapped the geology of that region.

In 1854 Dr. Rubidge was requested by the merchants of Port Elizabeth to visit and report upon the newly discovered gold-diggings near Smithfield, in the Orange-River Sovereignty. In company with Mr. Paterson he made a careful examination of the spot, and found that gold in small quantities was associated with quartz in the meridonal set of trap-dykes there intersecting the Dicynodon or Karoo beds. In his clear and concise communication of these results to the Geological Society of London (Quart. Journ. vol. xi. p. 1 &c.), Dr. Rubidge mentions a fact that may be of interest in connexion with the possible origin of the diamonds that have of late been so profusely found in Orange-River territories, namely, that in the eastern ranges of the Stormberg, beyond Aliwal, the anthracitic coal of the Karoo beds has been converted into plumbago by the volcanic dykes. Hence it is possible that, by further change, purer carbon has been elicited from the carbonaceous matter by volcanic or metamorphic agency in the Natal ranges, and has been brought down in the form of *diamond* by the rivers, together with their common agate gravel, derived from the same igneous and often amygdaloidal rocks (see also his letter in the Journ. Geol. Soc. vol. xii. p. 237).

In the same year (1854), at the instance of a Mining Company, Dr. Rubidge went to Namaqualand, to report upon its metal-producing capabilities. The results are given by him in the Geological Society's Journ. vol. xiii., a short notice only appearing in the previous volume. The gneissic and schistose rocks of this part of Western Africa being quite new to him, and full of interesting mineralogical characters, afforded a rich field of observation; and he was particularly struck with the probable metamorphic origin of

some granite, and with the apparent silicification of some bands of schist, covered unconformably by sandstone, through which water had carried silica to replace the original felspar and mica of the gneissic bands below. This view of the metamorphic condition of some quartzites Dr. Rubidge regarded as a key to the elucidation of certain sections seen in different parts of South Africa, and considered by him to be of a very difficult nature, if left to be explained according to the usual view of geologists. Thus, in 1858 (Geol. Soc. Journ. vol. xv. p. 196), he explained the section of Mitchell's Pass, at the village of Ceres, otherwise than Mr. Bain had interpreted it; and regarded the great sandstone formation of Table Mountain as occurring again and again, in great patches of horizontal and unconformable beds, over the highly inclined schists and gneiss, both of the Cape and of Namaqualand, instead of dipping at Ceres down below the Devonian rocks of the Bokkeveld; and thus he made the schistose rocks of Cape Town, of the Bokkeveld, George, and southern Uitenhage (whence he got Devonian fossils) to be all of the same date. Certainly a great advance was made in proving the continuation of the Bokkeveld schists into the last-named district; but whether the schists and slates of the Cape come into the same category still requires careful inquiry.

Examining the neighbourhood of the Zuerberg, in occasional journeys, Dr. Rubidge endeavoured to throw light on the stratification and structure of that country, showing that the Lower Ecca beds are probably of Devonian age. For the illustration of his views on this matter, he sent several series of rocks and fossils to the Geological Society of London, and he communicated papers on the subject to that Society, to the 'Geologist,' to the British Associon, and to the periodicals of Port Elizabeth. In 1864 he visited England, and travelled to the north with the special view of studying schistose and quartzose rocks like those of the Zuerberg. He brought with him many new fossils, of Secondary age, from the Uitenhage district, and went to considerable expense in getting them properly examined and determined, intending ultimately to produce a general work on the geology of the colony. The fossils constituted a valuable addition to the South-African collection in the Geological Society's Museum, and were fully described, with illustrations, in the Society's Journal, by Mr. R. Tate, in 1867.

So long ago as 1854, Dr. Rubidge wrote to his geological correspondents in London on the subject of aërial denudation, which had not then received so much attention from European geologists as it deserved. In 1866 he reproduced the chief points of his letters in the 'Geological Magazine,' No. 20, bringing forward evidence of the enormously extensive and long-continued denudation of the interior of South Africa, subsequent to its leaving the sea and since the lacustrine deposits of the Karoo formations were drained dry.

As an observer and as a generalizer, then, Dr. Rubidge was energetic and bold, adding much to the store of geological facts and thought, though working hard throughout in his professional prac-

tice, and often suffering from ill health. Heart disease has taken him off suddenly (at the age of about forty-eight) from amongst his friends, before his well-loved work was finished as he wished; but he had always given his best attention to the advancement of science in general, and of geology in particular, among the community around him; and having always identified himself with the Literary and Scientific Institutions of Port Elizabeth, and showed the greatest personal interest in its public Library, Museum, and public Hospital, his townsmen, who, in large numbers of all grades of society attended his funeral, regret him as a kind warm-hearted friend,—a loss which will not be readily replaced.—(T. R. J.)

Captain L. L. Boscawen Ibbetson died on the 8th of September, 1869, at Biebrich, in Prussia, where he had resided for several years. Whilst a resident in this country, Capt. Ibbetson was on terms of intimate friendship with the late Prof. Edward Forbes, in conjunction with whom he communicated to this Society a description of the section between Blackgang Chine and Atherfield Point, in the Isle of Wight, which was published in the first volume of our Quarterly Journal. He also communicated to the Dresden Natural-History Society, Isis, a notice of the Cretaceous formation of the Isle of Wight, and presented several papers on geological subjects to the British Association. For many years Capt. Ibbetson devoted much of his attention to the preparation of models of various interesting sections of country, and to the application of the electrotype process to the coating of perishable natural-history specimens with metal, in order to preserve accurate representations of them.

Capt. Ibbetson presented his valuable collection of fossils to the Museum of Practical Geology many years before his death.

E. W. Brayley, F.R.S., F.L.S., for many years Librarian to the London Institution, was a pupil of Prof. Brande at the Royal Institution, and as early as the year 1824 published, in the 'Philosophical Magazine,' a paper on luminous meteors, a subject which occupied his attention nearly to the close of his life. His principal contribution to our science is his paper on the formation of rock-basins, published in the 'Philosophical Magazine' in 1830. Mr. Brayley possessed a wide range of knowledge, and his printed memoirs, although not numerous, include papers on Physics, Astronomy, Chemistry, Zoology, and Meteorology. He died rather suddenly on the 1st of February, 1870.

John Nash Sanders was one of a small body of enlightened citizens who, as long ago as during the first decade of the present century, established a Bristol Philosophical Society; and the foundation of the noble Institution which in 1820 sprang out of that combination, and which now boasts a museum that is rich in many and unique in some objects, may be ascribed mainly to efforts which

he used in combination with one who in his lifetime was honoured as a ripe scholar and a man of cultivated taste, Mr. John Scandret Harford, of Blaize Castle. Mr. Sanders gave some £200 as a first subscription towards the building-fund, and beyond that we have reason to know that he supplied a deficiency which would have resulted from the breach of his promise by one who had undertaken to subscribe £100. Somewhat early in the history of the Institution he was elected to a distinguished honorary position in connexion with it, and for many years, and till the day of his death, he was one of its vice-presidents. His attachment to the undertaking, and to the important educational objects sought by it, never ceased. He was always a willing subscriber to its funds; and about nine years ago, when it became questionable whether the Museum could be kept up, he gave the princely sum of £1000 towards an Endowment Fund, to be applied to its future maintenance. To the force of his public-spirited example on that occasion the citizens of Bristol are mainly indebted for the preservation and rearrangement of a host of treasures which, thanks also to the untiring zeal of his nephew, Mr. William Sanders, F.G.S., Honorary Curator, are known to and prized by men of science throughout the empire. At the time of his death Mr. Sanders was in the 94th year of his age; but, with the exception of partial deafness, he retained his faculties almost to the last, and within a couple of months of his death he could read small type without the aid of spectacles.

It is now eight years since, in the absence of the late Mr. Leonard Horner, who then presided over us, it fell to my lot, as one of the Secretaries of this Society, to draw up the customary Annual Address. I availed myself of the opportunity to endeavour to "take stock" of that portion of the science of biology which is commonly called "palæontology," as it then existed; and, discussing one after another the doctrines held by palæontologists, I put before you the results of my attempts to sift the well-established from the hypothetical or the doubtful. Permit me briefly to recall to your minds what those results were:—

1. The living population of all parts of the earth's surface which have yet been examined has undergone a succession of changes which, upon the whole, have been of a slow and gradual character.

2. When the fossil remains which are the evidences of these successive changes, as they have occurred in any two more or less distant parts of the surface of the earth, are compared, they exhibit a certain broad and general parallelism. In other words, certain forms of life in one locality occur in the same general order of succession as, or are *homotaxial* with, similar forms in the other locality.

3. Homotaxis is not to be held identical with synchronism without independent evidence. It is possible that similar, or even iden-

tical, faunæ and floræ in two different localities may be of extremely different ages, if the term "age" is used in its proper chronological sense. I stated that "geographical provinces, or zones, may have been as distinctly marked in the Palæozoic epoch as at present; and those seemingly sudden appearances of new genera and species, which we ascribe to new creation, may be simple results of migration."

4. The opinion that the oldest known fossils are the earliest forms of life has no solid foundation.

5. If we confine ourselves to positively ascertained facts, the total amount of change in the forms of animal and vegetable life since the existence of such forms is recorded is small. When compared with the lapse of time since the first appearance of these forms, the amount of change is wonderfully small. Moreover, in each great group of the animal and vegetable kingdoms, there are certain forms which I termed Persistent Types, which have remained, with but very little apparent change, from their first appearance to the present time.

7. In answer to the question "What, then, does an impartial survey of the positively ascertained truths of palæontology testify in relation to the common doctrines of progressive modification, which suppose that modification to have taken place by a necessary progress from more to less embryonic forms, from more to less generalized types, within the limits of the period represented by the fossiliferous rocks?" I reply, "It negatives these doctrines; for it either shows us no evidence of such modification, or demonstrates such modification as has occurred to have been very slight; and, as to the nature of that modification, it yields no evidence whatsoever that the earlier members of any long-continued group were more generalized in structure than the later ones."

I think that I cannot employ my last opportunity of addressing you, officially, more properly—I may say more dutifully—than in revising these old judgments with such help as further knowledge and reflection, and an extreme desire to get at the truth, may afford me.

1. With respect to the first proposition, I may remark that whatever may be the case among the physical geologists, catastrophic palæontologists are practically extinct. It is now no part of recognized geological doctrine that the species of one formation all died out and were replaced by a bran-new set in the next formation. On the contrary, it is generally, if not universally, agreed that the succession of life has been the result of a slow and gradual replacement of species by species; and that all appearances of abruptness of change are due to breaks in the series of deposits, or other changes in physical conditions. The continuity of living forms has been unbroken from the earliest times to the present day.

2, 3. The use of the word "homotaxis" instead of "synchronism" has not, so far as I know, found much favour in the eyes of geologists. I hope, therefore, that it is a love for scientific caution, and not mere personal affection for a bantling of my own, which leads me still to think that the change of phrase is of importance, and that the sooner it is made, the sooner shall we get rid of a

number of pitfalls which beset the reasoner upon the facts and theories of geology.

One of the latest pieces of foreign intelligence which has reached us is the information that the Austrian geologists have, at last, succumbed to the weighty evidence which M. Barrande has accumulated, and have admitted the doctrine of colonies. But the admission of the doctrine of colonies implies the further admission that even identity of organic remains is no proof of the synchronism of the deposits which contain them.

4. The discussions touching the *Eozoon*, which commenced in 1864, have abundantly justified the fourth proposition. In 1862, the oldest record of life was in the Cambrian rocks; but if the *Eozoon* be, as Principal Dawson and Dr. Carpenter have shown so much reason for believing, the remains of a living being, the discovery of its true nature carried life back to a period which, as Sir William Logan has observed, is as remote from that during which the Cambrian rocks were deposited, as the Cambrian epoch itself is from the tertiaries. In other words, the ascertained duration of life upon the globe was nearly doubled at a stroke.

5. The significance of persistent types, and of the small amount of change which has taken place even in those forms which can be shown to have been modified, becomes greater and greater in my eyes, the longer I occupy myself with the biology of the past.

Consider how long a time has elapsed since the Miocene epoch. Yet, at that time, there is reason to believe that every important group in every order of the *Mammalia* was represented. Even the comparatively scanty Eocene fauna yields examples of the orders *Chiroptera*, *Insectivora*, *Rodentia*, and *Perissodactyla*; of *Artiodactyla* under both the Ruminant and the Porcine modifications; of *Carnivora*, *Cetacea*, and *Marsupialia*.

Or, if we go back to the older half of the Mesozoic epoch, how truly surprising it is to find every order of the *Reptilia*, except the *Ophidia*, represented; while some groups, such as the *Ornithoscelida* and the *Pterosauria*, more specialized than any which now exist, abounded.

There is one division of the *Amphibia* which offers especially important evidence upon this point, inasmuch as it bridges over the gap between the Mesozoic and the Palæozoic formations, often supposed to be of such prodigious magnitude, extending, as it does, from the bottom of the Carboniferous series to the top of the Trias, if not into the Lias. I refer to the Labyrinthodonts. As the address of 1862 was passing through the press, I was able to mention, in a note, the discovery of a large Labyrinthodont, with well-ossified vertebræ, in the Edinburgh coal-field. Since that time eight or ten distinct genera of Labyrinthodonts have been discovered in the Carboniferous rocks of England, Scotland, and Ireland, not to mention the American forms described by Principal Dawson and Professor Cope. So that, at the present time, the Labyrinthodont Fauna of the Carboniferous rocks is more extensive and diversified than that of the Trias, while its chief types, so far as osteology

enables us to judge, are quite as highly organized. Thus it is certain that a comparatively highly organized vertebrate type, such as that of the Labyrinthodonts, is capable of persisting, with no considerable change, through the period represented by the vast deposits which constitute the Carboniferous, the Permian, and the Triassic formations.

The very remarkable results which have been brought to light by the sounding and dredging operations, which have been carried on with such remarkable success by the expeditions sent out by our own, the American, and the Swedish Governments, under the supervision of able naturalists, have a bearing in the same direction. These investigations have demonstrated the existence, at great depths in the ocean, of living animals in some cases identical with, in others very similar to, those which are found fossilized in the white chalk. The *Globigerinæ*, Coccoliths, Coccospheres, Discoliths in the one are absolutely identical with those in the other; there are identical, or closely analogous, species of Sponges, Echinoderms, and Brachiopods. Off the coast of Portugal, there now lives a species of *Beryx*, which, doubtless, leaves its bones and scales here and there in the Atlantic ooze, as its predecessor left its spoils in the mud of the sea of the Cretaceous epoch.

Many years ago* I ventured to speak of the Atlantic mud as "modern chalk," and I know of no fact inconsistent with the view which Professor Wyville Thomson has advocated, that the modern chalk is not only the lineal descendant of the ancient chalk, but that it remains, so to speak, in the possession of the ancestral estate; and that from the Cretaceous period (if not much earlier) to the present day, the deep sea has covered a large part of what is now the area of the Atlantic. But if *Globigerina*, and *Terebratula caput-serpentis* and *Beryx*, not to mention other forms of animals and of plants, thus bridge over the interval between the present and the Mesozoic periods, is it possible that the majority of other living things underwent a "sea-change into something new and strange" all at once?

7. Thus far I have endeavoured to expand and to enforce by fresh arguments, but not to modify in any important respect, the ideas submitted to you on a former occasion. But when I come to the propositions touching progressive modification, it appears to me, with the help of the new light which has broken from various quarters, that there is much ground for softening the somewhat Brutus-like severity with which, in 1862, I dealt with a doctrine, for the truth of which I should have been glad enough to be able to find a good foundation. So far, indeed, as the *Invertebrata* and the lower *Vertebrata* are concerned, the facts and the conclusions which are to be drawn from them, appear to me to remain what they were. For anything that, as yet, appears to the contrary, the earliest known Marsupials may have been as highly organized as their living congeners; the Permian lizards show no

* 'Saturday Review,' 1858, "Chalk, Ancient and Modern."

signs of inferiority to those of the present day; the Labyrinthodonts cannot be placed below the living Salamander and Triton; the Devonian Ganoids are closely related to *Polypterus* and to *Lepidosiren*.

But when we turn to the higher *Vertebrata*, the results of recent investigations, however we may sift and criticize them, seem to me to leave a clear balance in favour of the doctrine of the evolution of living forms one from another. In discussing this question, however, it is very necessary to discriminate carefully between the different kinds of evidence from fossil remains which are brought forward in favour of evolution.

Every fossil which takes an intermediate place between forms of life already known, may be said, so far as it is intermediate, to be evidence in favour of evolution, inasmuch as it shows a possible road by which evolution may have taken place. But the mere discovery of such a form does not, in itself, prove that evolution took place by and through it, nor does it constitute more than presumptive evidence in favour of evolution in general. Suppose A, B, C to be three forms, of which B is intermediate in structure between A and C. Then the doctrine of evolution offers four possible alternatives. A may have become C by way of B; or C may have become A by way of B; or A and C may be independent modifications of B; or A, B, and C may be independent modifications of some unknown D. Take the case of the Pigs, the *Anoplotheriidæ*, and the Ruminants. The *Anoplotheriidæ* are intermediate between the first and the last; but this does not tell us whether the Ruminants have come from the Pigs, or the Pigs from Ruminants, or both from *Anoplotheriidæ*, or whether Pigs, Ruminants, and *Anoplotheriidæ* alike may not have diverged from some common stock.

But if it can be shown that A, B, and C exhibit successive stages in the degree of modification, or specialization, of the same type, and if, further, it can be proved that they occur in successively newer deposits, A being in the oldest, and C in the newest, then the intermediate character of B has quite another importance, and I should accept it, without hesitation, as a link in the genealogy of C. I should consider the burden of proof to be thrown upon any one who denied C to have been derived from A by way of B, or in some closely analogous fashion; for it is always probable that one may not hit upon the exact line of filiation, and, in dealing with fossils, may mistake uncles and nephews for fathers and sons.

I think it necessary to distinguish between the former and the latter classes of intermediate forms, as *intercalary types* and *linear types*. When I apply the former term, I merely mean to say that, as a matter of fact, the form B, so named, is intermediate between the others, in the sense in which the *Anoplotherium* is intermediate between the Pigs and the Ruminants—without either affirming, or denying, any direct genetic relation between the three forms involved. When I apply the latter term, on the other hand, I mean to express the opinion that the forms A, B, and C constitute a line of descent, and that B is thus part of the lineage of C.

From the time when Cuvier's wonderful researches upon the extinct Mammals of the Paris gypsum first made intercalary types known, and caused them to be recognized as such, the number of such forms has steadily increased among the higher *Mammalia*. Not only do we now know numerous intercalary forms of *Ungulata*, but M. Gaudry's great monograph upon the fossils of Pikermi (which strikes me as one of the most perfect pieces of palæontological work I have seen for a long time) shows us, among the *Primates*, *Mesopithecus* as an intercalary form between the *Semnopitheci* and the *Macaci*; and among the *Carnivora*, *Hyænictis* and *Ictitherium* as intercalary, or, perhaps, linear types between the *Viverridæ* and the *Hyænidæ*.

Hardly any order of the higher *Mammalia* stands so apparently separate and isolated from the rest as that of the *Cetacea*; though a careful consideration of the structure of the pinnipede *Carnivora*, or Seals, shows, in them, many an approximation towards the still more completely marine mammals. The extinct *Zeuglodon*, however, presents us with an intercalary form between the type of the Seals and that of the Whales. The skull of this great Eocene sea-monster, in fact, shows—by the narrow and prolonged interorbital region; the extensive union of the parietal bones in a sagittal suture; the well-developed nasal bones; the distinct and large incisors implanted in premaxillary bones, which take a full share in bounding the fore part of the gape; the two-fanged molar teeth with triangular and serrated crowns, not exceeding five on each side in each jaw; and the existence of a deciduous dentition—its close relation with the Seals. While, on the other hand, the produced rostral form of the snout, the long symphysis, and the low coronary process of the mandible are approximations to the cetacean form of those parts.

The scapula resembles that of the cetacean *Hyperoodon*, but the supraspinous fossa is larger and more seal-like; as is the humerus, which differs from that of the *Cetacea* in presenting true articular surfaces for the free jointing of the bones of the forearm. In the apparently complete absence of hinder limbs, and in the characters of the vertebral column, the *Zeuglodon* lies on the cetacean side of the boundary line; so that, upon the whole, the Zeuglodonts, transitional as they are, are conveniently retained in the cetacean order. And the publication, in 1864, of M. Van Beneden's memoir on the Miocene and Pliocene *Squalodon*, furnished much better means than anatomists previously possessed of fitting in another link of the chain which connects the existing *Cetacea* with *Zeuglodon*. The teeth are much more numerous, although the molars exhibit the zeuglodont double fang; the nasal bones are very short, and the upper surface of the rostrum presents the groove, filled up during life by the prolongation of the ethmoidal cartilage, which is so characteristic of the majority of the *Cetacea*.

It appears to me that, just as among the existing *Carnivora*, the walruses and the eared seals are intercalary forms between the fissipede Carnivora and the ordinary seals, so the Zeuglodons are

intercalary between the *Carnivora*, as a whole, and the *Cetacea*. Whether the Zeuglodonts are also linear types in their relation to these two groups cannot be ascertained, until we have more definite knowledge than we possess at present, respecting the relations in time of the *Carnivora* and *Cetacea*.

Thus far we have been concerned with the intercalary types which occupy the intervals between Families or Orders of the same class; but the investigations which have been carried on by Prof. Gegenbaur, Prof. Cope, and myself into the structure and relations of the extinct reptilian forms of the *Ornithoscelida* (or *Dinosauria* and *Compsognatha*) have brought to light the existence of intercalary forms between what have hitherto been always regarded as very distinct classes of the vertebrate subkingdom, namely *Reptilia* and *Aves*. Whatever inferences may, or may not, be drawn from the fact, it is now an established truth that in many of these *Ornithoscelida* the hind limbs and the pelvis are much more similar to those of Birds than they are to those of Reptiles, and that these Bird-reptiles or Reptile-birds were more or less completely bipedal.

When I addressed you in 1862, I should have been bold indeed had I suggested that palæontology would before long show us the possibility of a direct transition from the type of the lizard to that of the ostrich. At the present moment we have, in the *Ornithoscelida*, the intercalary type, which proves that transition to be something more than a possibility; but it is very doubtful whether any of the genera of *Ornithoscelida* with which we are at present acquainted are the actual linear types by which the transition from the lizard to the bird was effected. These, very probably, are still hidden from us in the older formations.

Let us now endeavour to find some cases of true linear types, or forms which are intermediate between others because they stand in a direct genetic relation to them. It is no easy matter to find clear and unmistakable evidence of filiation among fossil animals; for, in order that such evidence should be quite satisfactory, it is necessary that we should be acquainted with all the most important features of the organization of the animals which are supposed to be thus related, and not merely with the fragments upon which the genera and species of the palæontologist are so often based. M. Gaudry has arranged the species of *Hyænidæ*, *Proboscidea*, *Rhinocerotidæ*, and *Equidæ* in their order of filiation from their earliest appearance in the Miocene epoch to the present time, and Professor Rütimeyer has drawn up similar schemes for the Oxen and other *Ungulata*—with what, I am disposed to think, is a fair and probable approximation to the order of nature. But, as no one is better aware than these two learned, acute, and philosophical biologists, all such arrangements must be regarded as provisional, except in those cases in which, by a fortunate accident, large series of remains are obtainable from a thick and wide-spread series of deposits. It is easy to accumulate probabilities—hard to make out some particular case in such a way that it will stand rigorous criticism.

After much search, however, I think that such a case is to be made out in favour of the pedigree of the Horses.

The genus *Equus* is represented as far back as the latter part of the Miocene epoch; but in deposits belonging to the middle of that epoch its place is taken by two other genera, *Hipparion* and *Anchitherium* *; and in the lowest Miocene and upper Eocene only the last genus occurs. A species of *Anchitherium* was referred by Cuvier to the *Palæotheria* under the name of *P. aurelianense*. The grinding-teeth are in fact very similar in shape and in pattern, and in the absence of any thick layer of cement, to those of some species of *Palæotherium*, especially Cuvier's *Palæotherium minus*, which has been formed into a separate genus, *Plagiolophus*, by Pomel. But in the fact that there are only six full-sized grinders in the lower jaw, the first premolar being very small, that the anterior grinders are as large as or rather larger than the posterior ones, that the second premolar has an anterior prolongation, and that the posterior molar of the lower jaw has, as Cuvier pointed out, a posterior lobe of much smaller size and different form, the dentition of *Anchitherium* departs from the type of the *Palæotherium*, and approaches that of the Horse.

Again, the skeleton of *Anchitherium* is extremely equine. M. Christol goes so far as to say that the description of the bones of the horse, or the ass, current in veterinary works, would fit those of *Anchitherium*. And, in a general way, this may be true enough; but there are some most important differences, which, indeed, are justly indicated by the same careful observer. Thus the ulna is complete throughout, and its shaft is not a mere rudiment, fused into one bone with the radius. There are three toes, one large in the middle and one small on each side. The femur is quite like that of a horse, and has the characteristic fossa above the external condyle. In the British Museum there is a most instructive specimen of the leg-bones, showing that the fibula was represented by the external malleolus and by a flat tongue of bone, which extends up from it on the outer side of the tibia, and is closely anchylosed with the latter bone †. The hind toes are three, like those of the fore leg; and the middle metatarsal bone is much less compressed from side to side than that of the horse.

In the *Hipparion* the teeth nearly resemble those of the Horses, though the crowns of the grinders are not so long; like those of the

* Hermann von Meyer gave the name of *Anchitherium* to *A. Ezquerræ*; and in his paper on the subject he takes great pains to distinguish the latter as the type of a new genus, from Cuvier's *Palæotherium d' Orleans*. But it is precisely the *Palæotherium d' Orleans* which is the type of Christol's genus *Hipparitherium*; and thus, though *Hipparitherium* is of later date than *Anchitherium*, it seemed to me to have a sort of equitable right to recognition when this address was written. On the whole, however, it seems most convenient to adopt *Anchitherium*.

† I am indebted to Mr. Gervais for a specimen which indicates that the fibula was complete, at any rate in some cases; and for a very interesting ramus of a mandible, which shows that, as in the *Palæotheria*, the hindermost milk-molar of the lower jaw was devoid of the posterior lobe which exists in the hindermost true molar.

Horses they are abundantly coated with cement. The shaft of the ulna is reduced to a mere style anchylosed throughout nearly its whole length with the radius, and appearing to be little more than a ridge on the surface of the latter bone until it is carefully examined. The front toes are still three, but the outer ones are more slender than in *Anchitherium*, and their hoofs smaller in proportion to that of the middle toe; they are, in fact, reduced to mere dew-claws, and do not touch the ground. In the leg, the distal end of the fibula is so completely united with the tibia that it appears to be a mere process of the latter bone, as in the Horses.

In *Equus*, finally, the crowns of the grinding-teeth become longer, and their patterns are slightly modified; the middle of the shaft of the ulna usually vanishes, and its proximal and distal ends anchylose with the radius. The phalanges of the two outer toes in each foot disappear, their metacarpal and metatarsal bones being left as the "splints."

The *Hipparion* has large depressions on the face in front of the orbits, like those for the "larmiers" of many ruminants; but traces of these are to be seen in some of the fossil horses from the Sewalik Hills; and, as Leidy's recent researches show, they are preserved in *Anchitherium*.

When we consider these facts, and the further circumstance that the Hipparions, the remains of which have been collected in immense numbers, were subject, as M. Gaudry and others have pointed out, to a great range of variation, it appears to me impossible to resist the conclusion that the types of the *Anchitherium*, of the *Hipparion*, and of the ancient Horses constitute the lineage of the modern Horses, the *Hipparion* being the intermediate stage between the other two, and answering to B in my former illustration.

The process by which the *Anchitherium* has been converted into *Equus* is one of specialization, or of more and more complete deviation from what might be called the average form of an ungulate mammal. In the Horses, the reduction of some parts of the limbs, together with the special modification of those which are left, is carried to a greater extent than in any other hoofed mammals. The reduction is less and the specialization is less in the *Hipparion*, and still less in the *Anchitherium*; but yet, as compared with other mammals, the reduction and specialization of parts in the *Anchitherium* remains great.

Is it not probable then, that, just as in the Miocene epoch, we find an ancestral equine form less modified than *Equus*, so, if we go back to the Eocene epoch, we shall find some quadruped related to the *Anchitherium*, as *Hipparion* is related to *Equus*, and consequently departing less from the average form?

I think that this desideratum is very nearly, if not quite, supplied by *Plagiolophus*, remains of which occur abundantly in some parts of the Upper and Middle Eocene formations. The patterns of the grinding-teeth of *Plagiolophus* are similar to those of *Anchitherium*, and their crowns are as thinly covered with cement; but the grinders diminish in size forwards, and the last lower molar has a

large hind lobe, convex outwards and concave inwards, as in *Palæotherium.* The ulna is complete and much larger than in any of the *Equidæ,* while it is more slender than in most of the true *Palæotheria;* it is fixedly united but not anchylosed with the radius. There are three toes in the fore limb, the outer ones being slender, but less attenuated than in the *Equidæ.* The femur is more like that of the *Palæotheria* than that of the horse, and has only a small depression above its outer condyle in the place of the great fossa which is so obvious in the *Equidæ.* The fibula is distinct, but very slender, and its distal end is anchylosed with the tibia. There are three toes on the hind foot having similar proportions to those on the fore foot. The principal metacarpal and metatarsal bones are flatter than they are in any of the *Equidæ;* and the metacarpal bones are longer than the metatarsals, as in the *Palæotheria.*

In its general form, *Plagiolophus* resembles a very small and slender horse*; and is totally unlike the reluctant, pig-like creature depicted in Cuvier's restoration of his *Palæotherium minus* in the 'Ossemens Fossiles.'

It would be hazardous to say that *Plagiolophus* is the exact radical form of the Equine quadrupeds; but I do not think there can be any reasonable doubt that the latter animals have resulted from the modification of some quadruped similar to *Plagiolophus.*

We have thus arrived at the Middle Eocene formation, and yet have traced back the Horses only to a three-toed stock; but these three-toed forms, no less than the Equine quadrupeds themselves, present rudiments of the two other toes which appertain to what I have termed the "average" quadruped. If the expectation raised by the splints of the Horses that, in some ancestor of the Horses, these splints would be found to be complete digits, has been verified, we are furnished with very strong reasons for looking for a no less complete verification of the expectation that the three-toed *Plagiolophus*-like "avus" of the horse must have had a five-toed "atavus" at some earlier period.

No such five-toed "atavus," however, has yet made its appearance among the few middle and older Eocene *Mammalia* which are known.

Another series of closely affiliated forms, though the evidence they afford is perhaps less complete than that of the Equine series, is presented to us by the *Dichobune* of the Eocene epoch, the *Cainotherium* of the Miocene, and the *Tragulidæ,* or so-called "Musk-deer," of the present day.

The *Tragulidæ* have no incisors in the upper jaw, and only six grinding-teeth on each side of each jaw; while the canine is moved up to the outer incisor, and there is a diastema, in the lower jaw. There are four complete toes on the hind foot, but the middle metatarsals usually become, sooner or later, anchylosed into a cannon

* Such, at least, is the conclusion suggested by the proportions of the skeleton figured by Cuvier and De Blainville; but perhaps something between a Horse and an Agouti would be nearest the mark.

bone. The navicular and the cuboid unite, and the distal end of the fibula is anchylosed with the tibia.

In *Cainotherium* and *Dichobune* the upper incisors are fully developed. There are seven grinders; the teeth form a continuous series without a diastema. The metatarsals, the navicular and cuboid, and the distal end of the fibula remain free. In the *Cainotherium*, also, the second metacarpal, is developed, but is much shorter than the third, while the fifth is absent or rudimentary. In this respect it resembles *Anoplotherium secundarium*. This circumstance, and the peculiar pattern of the upper molars in *Cainotherium*, lead me to hesitate in considering it as the actual ancestor of the modern *Tragulidæ*. If *Dichobune* has a four-toed fore foot (though I am inclined to suspect it resembles *Cainotherium*) it will be a better representative of the oldest forms of the Traguline series; but *Dichobune* occurs in the Middle Eocene and is, in fact, the oldest known artiodactyle mammal. Where, then, must we look for its five-toed ancestor?

If we follow down other lines of recent and tertiary *Ungulata*, the same question presents itself. The Pigs are traceable back through the Miocene epoch to the Upper Eocene, where they appear in the two well-marked forms of *Hyopotamus* and *Chœropotamus*; but *Hyopotamus* appears to have had only two toes.

Again, all the great groups of the Ruminants, the *Bovidæ*, *Antilopidæ*, *Camelopardalidæ*, and *Cervidæ*, are represented in the Miocene epoch, and so are the Camels. The Upper-Eocene *Anoplotherium*, which is intercalary between the Pigs and the *Tragulidæ*, has only two or, at most, three toes. Among the scanty mammals of the Lower Eocene formation we have the perissodactyle *Ungulata* represented by *Coryphodon*, *Hyracotherium*, and *Pliolophus*. Suppose for a moment, for the sake of following out the argument, that *Pliolophus* represents the primary stock of the Perissodactyles, and *Dichobune* that of the Artiodactyles (though I am far from saying that such is the case), then we find in the earliest fauna of the Eocene epoch to which our investigations carry us the two divisions of the *Ungulata* completely differentiated, and no trace of any common stock of both or five-toed predecessors to either. With the case of the Horses before us, justifying a belief in the production of new animal forms by modification of old ones, I see no escape from the necessity of seeking for these ancestors of the *Ungulata* beyond the limits of the Tertiary formations.

I could as soon admit special creation, at once, as suppose that the Perissodactyles and Artiodactyles had no five-toed ancestors. And when we consider how large a portion of the Tertiary period elapsed before *Anchitherium* was converted into *Equus*, it is difficult to escape the conclusion that a large proportion of time anterior to the Tertiary must have been expended in converting the common stock of the *Ungulata* into Perissodactyles and Artiodactyles.

The same moral is inculcated by the study of every other order of Tertiary monodelphous *Mammalia*. Each of these orders is represented in the Miocene epoch: the Eocene formation, as I have already said, contains *Chiroptera*, *Insectivora*, *Rodentia*, *Ungulata*,

Carnivora, and *Cetacea*. But the *Chiroptera* are extreme modifications of the *Insectivora*, just as the *Cetacea* are extreme modifications of the Carnivorous type; and therefore it is to my mind incredible that monodelphous *Insectivora* and *Carnivora* should not have been abundantly developed, along with *Ungulata*, in the Mesozoic epoch. But if this be the case, how much further back must we go to find the common stock of the monodelphous *Mammalia*? As to the *Didelphia*, if we may trust the evidence which seems to be afforded by their very scanty remains, a Hypsiprymnoid form existed at the epoch of the Trias, side by side with a carnivorous form. At the epoch of the Trias, therefore, the *Marsupialia* must have already existed long enough to have become differentiated into carnivorous and herbivorous forms. But the *Monotremata* are lower forms than the *Didelphia*, which last are intercalary between the *Ornithodelphia* and the *Monodelphia*. To what point of the Palæozoic epoch, then, must we, upon any rational estimate, relegate the origin of the *Monotremata*?

The investigation of the occurrence of the classes and of the orders of the *Sauropsida* in time points in exactly the same direction. If, as there is great reason to believe, true Birds existed in the Triassic epoch, the ornithoscelidous forms by which Reptiles passed into Birds must have preceded them. In fact there is, even at present, considerable ground for suspecting the existence of *Dinosauria* in the Permian formations; but, in that case, lizards must be of still earlier date. And if the very small differences which are observable between the *Crocodilia* of the older Mesozoic formations and those of the present day furnish any sort of approximation towords an estimate of the average rate of change among the *Sauropsida*, it is almost appalling to reflect how far back in Palæozoic times we must go before we can hope to arrive at that common stock from which the *Crocodilia*, *Lacertilia*, *Ornithoscelida*, and *Plesiosauria*, which had attained so great a development in the Triassic epoch, must have been derived.

The *Amphibia* and *Pisces* tell the same story. There is not a single class of vertebrated animals which, when it first appears, is represented by analogues of the lowest known members of the same class. Therefore, if there is any truth in the doctrine of evolution, every class must be vastly older than the first record of its appearance upon the surface of the globe. But if considerations of this kind compel us to place the origin of vertebrated animals at a period sufficiently distant from the Upper Silurian, in which the first Elasmobranchs and Ganoids occur, to allow of the evolution of such fishes as these from a Vertebrate as simple as the *Amphioxus*, I can only repeat that it is appalling to speculate upon the extent to which that origin must have preceded the epoch of the first recorded appearance of vertebrate life.

Such is the further commentary which I have to offer upon the statement of the chief results of palæontology which I formerly ventured to lay before you.

But the growth of knowledge in the interval makes me conscious of an omission of considerable moment in that statement, inasmuch as it contains no reference to the bearings of palæontology upon the theory of the distribution of life; nor takes note of the remarkable manner in which the facts of distribution, in present and past times, accord with the doctrine of evolution, especially in regard to land animals.

That connexion between palæontology and geology on the one hand, and the present distribution of terrestrial animals, which so strikingly impressed Mr. Darwin thirty years ago as to lead him to speak of a "law of succession of types," and of the wonderful relationship on the same continent between the dead and the living, has recently received much elucidation from the researches of Gaudry, of Rütimeyer, of Leidy, and of Alphonse Milne-Edwards, taken in connexion with the earlier labours of our lamented colleague Falconer; and it has been instructively discussed in the thoughtful and ingenious work of Mr. Andrew Murray 'On the Geographical Distribution of Mammals'*.

I propose to lay before you, as briefly as I can, the ideas to which a long consideration of the subject has given rise in my own mind.

If the doctrine of evolution is sound, one of its immediate consequences clearly is, that the present distribution of life upon the globe is the product of two factors, the one being the distribution which obtained in the immediately preceding epoch, and the other the character and the extent of the changes which have taken place in physical geography between the one epoch and the other; or, to put the matter in another way, the Fauna and Flora of any given area, in any given epoch, can consist only of such forms of life as are directly descended from those which constituted the Fauna and Flora of the same area in the immediately preceding epoch, unless the physical geography (under which I include climatal conditions) of the area has been so altered as to give rise to immigration of living forms from some other area.

The evolutionist, therefore, is bound to grapple with the following problem whenever it is clearly put before him:—Here are the Faunæ of the same area during successive epochs. Show good cause for believing either that these Faunæ have been derived from one another by gradual modification, or that the Faunæ have reached the area in question by migration from some area in which they have undergone their development.

I propose to attempt to deal with this problem, so far as it is exemplified by the distribution of the terrestrial *Vertebrata*, and I shall endeavour to show you that it is capable of solution in a sense entirely favourable to the doctrine of evolution.

* The paper "On the Form and Distribution of the Land-tracts during the Secondary and Tertiary periods respectively; and on the effect upon Animal Life which great changes in Geographical Configuration have probably produced," by Mr. Searles V. Wood, Jun., which was published in the 'Philosophical Magazine' in 1862, was unknown to me when this Address was written. It is well worthy of the most careful study.

I have elsewhere * stated at length the reasons which lead me to recognize four primary distributional provinces for the terrestrial *Vertebrata* in the present world, namely,—first, the *Novozelanian*, or New-Zealand province; secondly, the *Australian* province, including Australia, Tasmania, and the Negrito Islands; thirdly, *Austro-Columbia*, or South America plus North America as far as Mexico; and fourthly, the rest of the world, or *Arctogæa*, in which province America north of Mexico constitutes one subprovince, Africa south of the Sahara a second, Hindostan a third, and the remainder of the Old World a fourth.

Now the truth which Mr. Darwin perceived and promulgated as "the law of the succession of types" is, that in all these provinces the animals found in Pliocene or later deposits are closely affined to those which now inhabit the same provinces; and that, conversely, the forms characteristic of other provinces are absent. North and South America, perhaps, present one or two exceptions to the last rule, but they are readily susceptible of explanation. Thus, in Australia, the later Tertiary mammals are marsupials (possibly with exception of the Dog and a Rodent or two, as at present). In Austro-Columbia the later Tertiary fauna exhibits numerous and varied forms of Platyrrhine Apes, Rodents, Cats, Dogs, Stags, *Edentata*, and Opossums; but, as at present, no Catarrhine Apes, no Lemurs, no *Insectivora*, Oxen, Antelopes, Rhinoceroses, or *Didelphia* other than Opossums. And in the wide-spread Arctogæal province, the Pliocene and later mammals belong to the same groups as those which now exist in the province. The law of succession of types, therefore, holds good for the present epoch as compared with its predecessor. Does it equally well apply to the Pliocene fauna when we compare it with that of the Miocene epoch? By great good fortune an extensive mammalian fauna of this epoch has now become known, in four very distant portions of the Arctogæal province which do not differ greatly in latitude. Thus Falconer and Cautley have made known the fauna of the sub-Himalayas and the Perim Islands; Gaudry that of Attica; many observers that of Central Europe and France; and Leidy that of Nebraska, on the eastern flank of the Rocky Mountains. The results are very striking. The total Miocene fauna comprises many genera and species of Catarrhine Apes, of Bats, of *Insectivora*, of Arctogæal types of *Rodentia*, of *Proboscidea*, of equine, rhinocerotic, and tapirine quadrupeds, of cameline, bovine, antilopine, cervine, and traguline Ruminants, of Pigs and Hippopotamuses, of *Viverridæ* and *Hyænidæ* among other *Carnivora*, with *Edentata* allied to the Arctogæal *Orycteropus* and *Manis*, and not to the Austro-Columbian Edentates. The only type present in the Miocene, but absent in the existing fauna of Eastern Arctogæa is that of the *Didelphidæ*, which, however, remains in North America.

But it is very remarkable that while the Miocene fauna of the Arctogæal province, as a whole, is of the same character as the ex-

* "On the Classification and Distribution of the Alectoromorphæ," Proceedings of the Zoological Society, 1868.

isting fauna of the same province, as a whole, the component elements of the fauna were differently associated. In the Miocene epoch, North America possessed Elephants, Horses, Rhinoceroses, and a great number and variety of Ruminants and Pigs, which are absent in the present indigenous fauna; Europe had its Apes, Elephants, Rhinoceroses, Tapirs, Musk-deer, Giraffes, Hyænas, great Cats, Edentates, and Opossum-like Marsupials, which have equally vanished from its present fauna; and in Northern India, the African types of Hippopotamuses, Giraffes, and Elephants were mixed up with what are now the Asiatic types of the latter, and with Camels and Semnopithecine and Pithecine Apes of no less distinctly Asiatic forms.

In fact the Miocene mammalian fauna of Europe and the Himalayan regions contains, associated together, the types which are now separately located in the South-African and Indian subprovinces of Arctogæa. Now there is every reason to believe, on other grounds, that both Hindostan, south of the Ganges, and Africa, south of the Sahara, were separated by a wide sea from Europe and North Asia during the Middle and Upper Eocene epochs. Hence it becomes highly probable that the well-known similarities, and no less remarkable differences, between the present Faunæ of India and South Africa have arisen in some such fashion as the following. Some time during the Miocene epoch, possibly when the Himalayan chain was elevated, the bottom of the nummulitic sea was upheaved and converted into dry land, in the direction of a line extending from Abyssinia to the mouth of the Ganges. By this means, the Dekhan on the one hand, and South Africa on the other, became connected with the Miocene dry land and with one another. The Miocene mammals spread gradually over this intermediate dry land, and if the condition of its eastern and western ends offered as wide contrasts as the valleys of the Ganges and Arabia do now, many forms which made their way into Africa must have been different from those which reached the Dekhan, while others might pass into both these subprovinces.

That there was a continuity of dry land between Europe and North America during the Miocene epoch, appears to me to be a necessary consequence of the fact that many genera of terrestrial Mammals, such as *Castor*, *Hystrix*, *Elephas*, *Mastodon*, *Equus*, *Hipparion*, *Anchitherium*, *Rhinoceros*, *Cervus*, *Amphicyon*, *Hyænarctos*, and *Machairodus*, are common to the Miocene formations of the two areas, and have as yet been found (except perhaps *Anchitherium*) in no deposit of earlier age. Whether this connexion took place by the east, or by the west, or by both sides of the Old World, there is at present no certain evidence, and the question is immaterial to the present argument; but, as there are good grounds for the belief that the Australian province and the Indian and South-African subprovinces were separated by sea from the rest of Arctogæa before the Miocene epoch, so it has been rendered no less probable, by the investigations of Mr. Carrick Moore and Prof. Duncan, that Austro-Columbia was separated by sea from North America during a large part of the Miocene epoch.

It is unfortunate that we have no knowledge of the Miocene mammalian fauna of the Australian and Austro-Columbian provinces; but, seeing that not a trace of a Platyrrhine Ape, of a Procyonine Carnivore, of a characteristically South-American Rodent, of a Sloth, an Armadillo, or an Anteater has yet been found in Miocene deposits of Arctogæa, I cannot doubt that they already existed in the Miocene Austro-Columbian province.

Nor is it less probable that the characteristic types of Australian Mammalia were already developed in that region in Miocene times.

But Austro-Columbia presents difficulties from which Australia is free; *Camelidæ* and *Tapiridæ* are now indigenous in South America as they are in Arctogæa, and among the Pliocene Austro-Columbian mammals, the Austro-Columbian genera *Equus*, *Mastodon*, and *Machairodus* are numbered. Are these Postmiocene immigrants, or Præmiocene natives?

Still more perplexing are the strange and interesting forms *Toxodon*, *Macrauchenia*, and *Typotherium*, and a new Anoplotherioid mammal (*Homalodotherium*) which Dr. Cunningham sent over to me some time ago from Patagonia. I confess I am strongly inclined to surmise that these last, at any rate, are remnants of the population of Austro-Columbia before the Miocene epoch, and were not derived from Arctogæa by way of the north and east.

The fact that this immense fauna of Miocene Arctogæa is now fully and richly represented only in India and in South Africa, while it is shrunk and depauperized in North Asia, Europe, and North America, becomes at once intelligible, if we suppose that India and South Africa had but a scanty mammalian population before the Miocene immigration, while the conditions were highly favourable to the new comers. It is to be supposed that these new regions offered themselves to the Miocene Ungulates, as South America and Australia offered themselves to the cattle, sheep, and horses of modern colonists. But, after these great areas were thus peopled, came the Glacial epoch, during which the excessive cold, to say nothing of depression and ice-covering, must have almost depopulated all the northern parts of Arctogæa, destroying all the higher mammalian forms except those which, like the Elephant and Rhinoceros, could adjust their coats to the altered conditions. Even these must have been driven away from the greater part of the area; only those Miocene mammals which had passed into Hindostan and into South Africa would escape decimation by such changes in the physical geography of Arctogæa. And when the northern hemisphere passed into its present condition, these lost tribes of the Miocene Fauna were hemmed by the Himalayas, the Sahara, the Red Sea, and the Arabian deserts within their present boundaries.

Now, on the hypothesis of evolution, there is no sort of difficulty in admitting that the differences between the Miocene forms of the mammalian Fauna and those which exist now are the results of gradual modification; and, since such differences in distribution as obtain are readily explained by the changes which have taken place in the physical geography of the world since the Miocene epoch, it is

clear that the result of the comparison of the Miocene and present Faunæ is distinctly in favour of evolution. Indeed I may go further. I may say that the hypothesis of evolution explains the facts of Miocene, Pliocene, and Recent distribution, and that no other supposition even pretends to account for them. It is, indeed, a conceivable supposition that every species of Rhinoceros and every species of Hyæna, in the long succession of forms between the Miocene and the present species, was separately constructed out of dust, or out of nothing, by supernatural power; but until I receive distinct evidence of the fact, I refuse to run the risk of insulting any sane man by supposing that he seriously holds such a notion.

Let us now take a step further back in time, and inquire into the relations between the Miocene Fauna and its predecessor of the Upper Eocene formation.

Here it is to be regretted that our materials for forming a judgment are nothing to be compared in point of extent or variety with those which are yielded by the Miocene strata. However, what we do know of this Upper Eocene Fauna of Europe gives sufficient positive information to enable us to draw some tolerably safe inferences. It has yielded representatives of *Insectivora*, of *Chiroptera*, of *Rodentia*, of *Carnivora*, of artiodactyle and perissodactyle *Ungulata*, and of opossum-like Marsupials. No Australian type of Marsupial has been discovered in the Upper Eocene strata, nor any Edentate mammal. The genera (except in the case perhaps of some of the *Insectivora*, *Chiroptera*, and *Rodentia*) are different from those of the Miocene epoch, but present a remarkable general similarity to the Miocene and recent genera. In several cases, as I have already shown, it has now been clearly made out that the relation between the Eocene and Miocene forms is such that the Eocene form is the less specialized; while its Miocene ally is more so, and the specialization reaches its maximum in the recent forms of the same type.

So far as the Upper Eocene and the Miocene Mammalian Faunæ are comparable, their relations are such as in no way to oppose the hypothesis that the older are the progenitors of the more recent forms, while, in some cases, they distinctly favour that hypothesis. The period in time and the changes in physical geography represented by the nummulitic deposits are undoubtedly very great, while the remains of Middle Eocene and Older Eocene Mammals are comparatively few. The general facies of the Middle Eocene fauna, however, is quite that of the Upper. The Older Eocene pre-nummulitic mammalian Fauna contains Bats, two genera of *Carnivora*, three genera of *Ungulata* (probably all perissodactyle), and a didelphid Marsupial; all these forms, except perhaps the Bat and the Opossum, belong to genera which are not known to occur out of the Lower Eocene formation. The *Coryphodon*, however, appears to have been allied to the Miocene and later Tapirs, while *Pliolophus*, in its skull and dentition, curiously partakes of both artiodactyle and perissodactyle characters; the third trochanter upon its femur, and its three-toed hind foot, however, appear definitely to fix its position in the latter division.

There is nothing, then, in what is known of the older Eocene mammals of the Arctogæal province to forbid the supposition that they stood in an ancestral relation to those of the Calcaire Grossier and the Gypsum of the Paris basin, and that our present fauna, therefore, is directly derived from that which already existed in Arctogæa at the commencement of the Tertiary period. But if we now cross the frontier between the Cainozoic and the Mesozoic faunæ, as they are preserved within the Arctogæal area, we meet with an astounding change, and what appears to be a complete and unmistakable break in the line of biological continuity.

Among the twelve or fourteen species of *Mammalia* which are said to have been found in the Purbecks, not one is a member of the orders *Chiroptera*, *Rodentia*, *Ungulata*, or *Carnivora*, which are so well represented in the tertiaries. No *Insectivora* are certainly known, nor any opossum-like Marsupials. Thus there is a vast negative difference between the Cainozoic and the Mesozoic mammalian faunæ of Europe. But there is a still more important positive difference, inasmuch as all these Mammalia appear to be Marsupials belonging to Australian groups, and thus appertaining to a different distributional province from the Eocene and Miocene marsupials, which are Austro-Columbian. So far as the imperfect materials which exist enable a judgment to be formed, the same law appears to have held good for all the earlier Mesozoic *Mammalia*. Of the Stonesfield slate mammals, one, *Amphitherium*, has a definitely Australian character; one, *Phascolotherium*, may be either Dasyurid or Didelphine; of a third, *Stereognathus*, nothing can at present be said. The two mammals of the Trias, also, appear to belong to Australian groups.

Every one is aware of the many curious points of resemblance between the marine fauna of the European Mesozoic rocks and that which now exists in Australia. But if there was this Australian facies about both the terrestrial and the marine faunæ of Mesozoic Europe, and if there is this unaccountable and immense break between the fauna of Mesozoic and that of Tertiary Europe, is it not a very obvious suggestion that, in the Mesozoic epoch, the Australian province included Europe, and that the Arctogæal province was contained within other limits? The Arctogæal province is at present enormous, while the Australian is relatively small. Why should not these proportions have been different during the Mesozoic epoch?

Thus I am led to think that by far the simplest and most rational mode of accounting for the great change which took place in the living inhabitants of the European area at the end of the Mesozoic epoch is the supposition that it arose from a vast alteration of the physical geography of the globe, whereby an area long tenanted by Cainozoic forms was brought into such relations with the European area that migration from the one to the other became possible, and took place on a great scale.

This supposition relieves us, at once, from the difficulty in which we were left, some time ago, by the arguments which I used to

demonstrate the necessity of the existence of all the great types of the Eocene epoch in some antecedent period.

It is this Mesozoic continent (which may well have lain in the neighbourhood of what are now the shores of the North Pacific Ocean) which I suppose to have been occupied by the Mesozoic *Monodelphia*; and it is in this region that I conceive they must have gone through the long series of changes by which they were specialized into the forms which we refer to different orders. I think it very probable that what is now South America may have received the characteristic elements of its mammalian fauna during the Mesozoic epoch; and there can be little doubt that the general nature of the change which took place at the end of the Mesozoic epoch in Europe was the upheaval of the eastern and northern regions of the Mesozoic sea-bottom into a westward extension of the Mesozoic continent, over which the mammalian fauna, by which it was already peopled, gradually spread. This invasion of the land was prefaced by a previous invasion of the Cretaceous sea by modern forms of mollusca and fish.

It is easy to imagine how an analogous change might come about in the existing world. There is, at present, a great difference between the fauna of the Polynesian Islands and that of the west coast of America. The animals which are leaving their spoils in the deposits now forming in these localities are widely different. Hence, if a gradual shifting of the deep sea, which at present bars migration between the easternmost of these islands and America took place to the westward, while the American side of the sea-bottom was gradually upheaved, the palæontologist of the future would find, over the Pacific area, exactly such a change as I am supposing to have occurred in the North-Atlantic area at the close of the Mesozoic period. An Australian fauna would be found underlying an American fauna, and the transition from the one to the other would be as abrupt as that between the Chalk and lower Tertiaries; and as the drainage-area of the newly formed extension of the American continent gave rise to rivers and lakes, the mammals mired in their mud would differ from those of like deposits on the Australian side just as the Eocene mammals differ from those of the Purbecks.

How do similar reasonings apply to the other great change of life —that which took place at the end of the Palæozoic period?

In the Triassic epoch, the distribution of the dry land and of terrestrial vertebrate life appears to have been, generally, similar to that which existed in the Mesozoic epoch; so that the Triassic continents and their faunæ seem to be related to the Mesozoic lands and their faunæ, just as those of the Miocene epoch are related to those of the present day. In fact, as I have recently endeavoured to prove to the Society, there was an Arctogæal continent and an Arctogæal province of distribution in Triassic times as there is now; and the *Sauropsida* and *Marsupialia* which constituted that fauna were, I doubt not, the progenitors of the *Sauropsida* and *Marsupialia* of the whole Mesozoic epoch.

Looking at the present terrestrial fauna of Australia, it appears to me to be very probable that it is essentially a remnant of the fauna of the Triassic, or even of an earlier, age *; in which case Australia must at that time have been in continuity with the Arctogæal continent.

But now comes the further inquiry, Where was the highly differentiated Sauropsidan fauna of the Trias in Palæozoic times? The supposition that the Dinosaurian, Crocodilian, Dicynodontian, and Plesiosaurian types were suddenly created at the end of the Permian epoch may be dismissed, without further consideration, as a monstrous and unwarranted assumption. The supposition that all these types were rapidly differentiated out of *Lacertilia*, in the time represented by the passage from the Palæozoic to the Mesozoic formation, appears to me to be hardly more credible, to say nothing of the indications of the existence of Dinosaurian forms in the Permian rocks which have already been obtained.

For my part, I entertain no sort of doubt that the Reptiles, Birds, and Mammals of the Trias are the direct descendants of Reptiles, Birds, and Mammals which existed in the latter part of the Palæozoic epoch, but not in any area of the present dry land which has yet been explored by the geologist.

This may seem a bold assumption, but it will not appear unwarrantable to those who reflect upon the very small extent of the earth's surface which has hitherto exhibited the remains of the great Mammalian fauna of the Eocene times. In this respect, the Permian land Vertebrate fauna appears to me to be related to the Triassic much as the Eocene is to the Miocene. Terrestrial reptiles have been found in Permian rocks only in three localities, in some spots of France, and recently of England, and over a more extensive area in Germany. Who can suppose that the few fossils yet found in these regions give any sufficient representation of the Permian fauna?

It may be said that the Carboniferous formations demonstrate the existence of a vast extent of dry land in the present dry-land area, and that the supposed terrestrial Palæozoic Vertebrate Fauna ought to have left its remains in the Coal-measures, especially as there is now reason to believe that much of the coal was formed by the accumulation of spores and sporangia on dry land. But if we consider the matter more closely, I think that this apparent objection loses its force. It is clear that, during the Carboniferous epoch, the vast area of land which is now covered by Coal-measures must have been undergoing a gradual depression. The dry land thus depressed must, therefore, have existed, as such, before the Carboniferous epoch—in other words, in Devonian times—and its terrestrial population may never have been other than such as existed during the Devonian, or some previous epoch, although much higher forms may have been developed elsewhere.

* Since this Address was read, Mr. Krefft has sent us news of the discovery in Australia of a freshwater fish of strangely Palæozoic aspect, and apparently a Ganoid intermediate between *Dipterus* and *Lepidosiren*.

Again, let me say that I am making no gratuitous assumption of inconceivable changes. It is clear that the enormous area of Polynesia is, on the whole, an area over which depression has taken place to an immense extent; consequently a great continent, or assemblage of subcontinental masses of land, must have existed at some former time, and that at a recent period, geologically speaking, in the area of the Pacific. But if that continent had contained mammals, some of them must have remained to tell the tale; and as it is well known that these islands have no indigenous *Mammalia*, it is safe to assume that none existed. Thus, midway between Australia and South America, each of which possesses an abundant and diversified mammalian fauna, a mass of land, which may have been as large as both put together, must have existed without a mammalian inhabitant. Suppose that the shores of this great land were fringed, as those of tropical Australia are now, with belts of mangroves, which would extend landwards on the one side, and be buried beneath littoral deposits on the other side, as depression went on; and great beds of mangrove lignite might accumulate over the sinking land. Let upheaval of the whole now take place, in such a manner as to bring the emerging land into continuity with the South-American or Australian continent, and, in course of time, it would be peopled by an extension of the fauna of one of these two regions—just as I imagine the European Permian dry land to have been peopled.

I see nothing whatever against the supposition that distributional provinces of terrestrial life existed in the Devonian epoch, inasmuch as M. Barrande has proved that they existed much earlier. I am aware of no reason for doubting that, as regards the grades of terrestrial life contained in them, one of these may have been related to another as New Zealand is to Australia, or as Australia is to India, at the present day. Analogy seems to me to be rather in favour of, than against, the supposition that while only Ganoid fishes inhabited the fresh waters of our Devonian land, *Amphibia* and *Reptilia*, or even higher forms, may have existed, though we have not yet found them. The earliest Carboniferous *Amphibia* now known, such as *Anthracosaurus*, are so highly specialized that I can by no means conceive that they have been developed out of piscine forms in the interval between the Devonian and the Carboniferous periods, considerable as that is. And I take refuge in one of two alternatives: either they existed in our own area during the Devonian epoch and we have simply not yet found them, or they formed part of the population of some other distributional province of that day, and only entered our area by migration at the end of the Devonian epoch. Whether *Reptilia* and *Mammalia* existed along with them is to me, at present, a perfectly open question, which is just as likely to receive an affirmative as a negative answer from future inquirers.

Let me now gather together the threads of my argumentation into the form of a connected hypothetical view of the manner in which the distribution of living and extinct animals has been brought about.

I conceive that distinct provinces of the distribution of terrestrial life have existed since the earliest period at which that life is recorded, and possibly much earlier; and I suppose, with Mr. Darwin, that the progress of modification of terrestrial forms is more rapid in areas of elevation than in areas of depression. I take it to be certain that Labyrinthodont *Amphibia* existed in the distributional province which included the dry land depressed during the Carboniferous epoch; and I conceive that, in some other distributional provinces of that day, which remained in the condition of stationary or of increasing dry land, the various types of the terrestrial *Sauropsida* and of the *Mammalia* were gradually developing.

The Permian epoch marks the commencement of a new movement of upheaval in our area, which attained its maximum in the Triassic epoch, when dry land existed in North America, Europe, Asia, and Africa, as it does now. Into this great new continental area the Mammals, Birds, and Reptiles developed during the Palæozoic epoch spread, and formed the great Triassic Arctogæal province. But, at the end of the Triassic period, the movement of depression recommenced in our area, though it was doubtless balanced by elevation elsewhere; modification and development, checked in the one province, went on in that "elsewhere"; and the chief forms of Mammals, Birds, and Reptiles, as we know them, were evolved and peopled the Mesozoic continent. I conceive Australia to have become separated from the continent as early as the end of the Triassic epoch, or not much later. The Mesozoic continent must, I conceive, have lain to the east, about the shores of the North Pacific and Indian Oceans; and I am inclined to believe that it continued along the eastern side of the Pacific area to what is now the province of Austro-Columbia, the characteristic Fauna of which is probably a remnant of the population of the latter part of this period.

Towards the latter part of the Mesozoic period the movement of upheaval around the shores of the Atlantic once more recommenced, and was very probably accompanied by a depression around those of the Pacific. The Vertebrate fauna elaborated in the Mesozoic continent moved westward and took possession of the new lands, which gradually increased in extent up to, and in some directions after, the Miocene epoch.

It is in favour of this hypothesis, I think, that it is consistent with the persistence of a general uniformity in the positions of the great masses of land and water. From the Devonian period, or earlier, to the present day, the four great oceans, Atlantic, Pacific, Arctic, and Antarctic, may have occupied their present positions, and only their coasts and channels of communication have undergone an incessant alteration. And, finally, the hypothesis I have put before you requires no supposition that the rate of change in organic life has been either greater or less in ancient times than it is now; nor any assumption, either physical or biological, which has not its justification in analogous phenomena of existing nature.

I have now only to discharge the last duty of my office, which is

to thank you, not only for the patient attention with which you have listened to me so long to-day, but also for the uniform kindness with which, for the past two years, you have rendered my endeavours to perform the important, and often laborious, functions of your President a pleasure instead of a burden.

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

November 10, 1869.

E. Hartley, Esq., of the Geological Survey of Canada, Montreal, was elected a Fellow of the Society.

The following communications were read :—

1. Australian Mesozoic Geology *and* Palæontology. By Charles Moore, Esq., F.G.S.

(The publication of this paper is deferred.)

[Abstract.]

The author referred to the observations of Professor M'Coy and the Rev. W. B. Clark on the occurrence of fossils of Mesozoic age in Australia, and then proceeded to notice the species which he had obtained from that region. Fossils of Mesozoic type occur both in Western Australia, in the centre of the Continent on Stuart's route, and in Queensland; but the specimens have hitherto been found in apparently drifted blocks, and nothing is known of the bedded rocks from which they are derived. The author stated that the Australian Mesozoic fossils agree, not only in genera, but also in many cases in species, with British forms ; and he gave a list of species from Western Australia, identical with British species from the Middle and Upper Lias, the Inferior Oolite, and the Cornbrash. Of the fossils from Queensland also, many are said to be identical with, or very nearly allied to, British species ; but the author regards

the general type of the Queensland remains as referring them to the Upper Oolite. A gigantic species of *Crioceras* is regarded by the author as possibly indicative of the occurrence of Neocomian deposits in Australia. The fossil evidence upon which Professor M'Coy inferred the occurrence of the Muschelkalk in Australia was said by the author to be nugatory, his supposed *Myophoria* proving to be a *Trigonia* nearly allied to *T. gibbosa* of the Portland Oolite, and his doubtful *Orthoceras* a small *Serpula*. The author had found no indications of the existence of Triassic or Liassic deposits in Queensland.

The blocks from Western Australia, referred by the author to the Middle Lias, contain *Myacites liassianus* (Quenst.), and are quite as highly ferruginous as the English Marlstone. The species identified by the author with British Oolitic species would indicate a range from the Inferior Oolite to the Cornbrash; the author suggested that the species may have had a longer range in time in Australia than in England, or that the subordinate divisions of the Oolite were not clearly marked in the Australian Mesozoic deposits. He is inclined to refer the fossils to the period of the Inferior Oolite.

The author inferred, from the occurrence of these Mesozoic fossils in drifted blocks at the two extremities of Australia, separated by 38° of longitude, that an enormous denudation of rocks of the secondary series has taken place over a considerable part of Australia.

Descriptions of a great number of new species were appended to the paper.

---

2. *On a* Plant- *and* Insect-bed *on the* Rocky River, New South Wales. By Charles Moore, Esq., F.G.S.

(The publication of this paper is deferred.)

[Abstract.]

The organic remains noticed by the author were found by him in a small block of chocolate-coloured micaceous laminated marl, obtained from a bed about ten feet thick, at a depth of 100–110 feet, in the auriferous drifts of Sydney flats, on the banks of the Rocky River. The author found the leaves of two forms of Dicotyledonous plants, fragments of a flat narrow leaf which he refers to the Coniferæ, a seed-vessel, and the impressions of several seeds. The insect-remains consist principally of the elytra of Beetles, among which Buprestidæ appear to predominate. The vegetable-remains seem to indicate that the deposit is of Tertiary age.

Discussion.

Prof. T. Rupert Jones mentioned the discovery of a large *Crioceras* in the Jurassic beds near Port Elizabeth.

Mr. W. Boyd Dawkins suggested that we had hardly a right to apply the European standard in judging fossils from all parts of the

world, and doubted whether, if these fossils were examined from the purely Australian point of view, the same age would be assigned to them.

Mr. Seeley agreed with Mr. Dawkins, and argued, from the existence of natural groups in different areas of the globe, and from the succession of life in time, that in no distant locality could the age of a rock be known from the resemblance of the fossils to an English type.

Mr. R. Tate remarked that if Mr. Moore had compared the Jurassic fauna with those of India, Africa, and Chili, he would have found the same mixture of forms belonging apparently to different horizons. He considered that the Australian fossils probably represented our Middle Oolite. He did not quite agree with the author as to some of the specific determinations.

Dr. Duncan remarked that the same combination of forms separated in Europe was found among the Tertiary fossils of Australia. He thought that further facts were necessary before forming a decided opinion as to the succession of the beds in that continent.

The President remarked that when we talked of identity of fauna in Australia and this country, improbable as it might appear, we must remember that at the present time identical species and, to a great extent, a similar fauna were to be found in our seas more than 180° apart.

Mr. Moore, in reply, argued that it was the safest plan to follow the well-established standard of Europe even in remote parts of the world. He was inclined to refer the bulk of the specimens rather to the Lower than to the Middle Oolite, but otherwise he agreed in the main with Mr. Tate.

---

3. *On* Hypsilophodon Foxii, *a* new Dinosaurian *from the* Wealden *of the* Isle *of* Wight. By T. H. Huxley, LL.D., F.R.S., President of the Society.

(Plates I. & II.)

During the meeting of the British Association at Norwich in 1868, Mr. F. Fellows, on behalf of the Rev. W. Fox, read a paper on, and exhibited the skull of, a fossil reptile discovered by that indefatigable explorer of the rocks of the Isle of Wight in a bed of the Wealden formation, "which forms the floor of Cowleaze Chine, and rises to the top of the sea cliff at Barne's High, in the parish of Brixton." Mr. Fox considered the reptile to be a "young *Iguanodon*," or more probably a "new small species of *Iguanodon*," and stated that he had found "several other skeletons" of the animal in the same locality.

In accordance with a wish expressed to me by Mr. Fellows, I made as careful an examination of the specimen as the circumstances would permit, and embodied the results of the investigation in some observations, accompanied by extemporaneous illustrations, which I made before Section C when the paper was read.

I pointed out the peculiar value of the skull, which arose from the nearly entire condition of the præmaxillary bones, which last had, up to that time, been displayed by no Dinosaurian fossil, except, perhaps, *Compsognathus*. I further drew attention to the singular fact that the incisor teeth, or those contained in the posterior moiety of each præmaxilla, were totally different in shape from the maxillary teeth; and that the anterior moiety of the præmaxilla was beak-like and edentulous. Moreover I expressed the opinion that while the affinity of the reptile with *Iguanodon* was clear, the extent of that affinity could only be determined by further critical comparisons.

I lost sight of the specimen for a long time; but, some months ago, hearing that it was in Mr. Fellows's keeping in London, I requested Mr. Fox's permission to subject it to more careful study. That permission was very readily and liberally accorded by Mr. Fox, and I now offer the results of this further work to the Society.

The skull (Pl. I. fig. 1), when entire and undistorted, must have had a length of rather less than four inches (probably about 3·8 or 3·9). The greater portion of the roof and of the right upper maxillary apparatus, with a part of the occipital surface, are displayed. The whole left nasal bone is exposed, together with part of the left præmaxilla and a portion of the left ramus of the mandible.

Two relatively large supratemporal fossæ, each about three-quarters of an inch long and four-tenths of an inch wide, lie at the sides of the parietal region, which is somewhat narrow in the middle, but expands at each end. The parietal bones (*Pa*) are a good deal injured, but they appear to have inclosed an oval median parietal foramen. In front, they unite by a transverse suture with the large frontal bones (*Fr*). Each of these is 1·4 inch long, 0·5 inch broad behind, and rather narrow in front, flattened though slightly concave from side to side, and somewhat convex from before backwards. The inner edges of the two frontal bones are a little raised where they unite in the frontal suture. The nasal bones (*Na*) are very large, being as long as the frontals, and very nearly as broad behind, where they are flattened and continue the direction of the roof of the skull. Anteriorly they narrow; and their outer surfaces, becoming convex, look somewhat outwards. Each nasal bone ends by a deeply concave rounded free margin, which bounds the nostril (*N*) above, and sends down a slender process on each side. The inner of these bounds the greater part of the inner side of the nostril, and lies upon, and internal to, the anterior ascending process of the præmaxillary bone (*Pmx*). The outer, in like manner, applies itself to the anterior edge of the ascending process of the maxillary, and forms a part of the outer boundary of the nostril.

The præmaxilla is a very large and remarkable bone. The body, or dentigerous portion, is 0·8 inch long and 0·3 inch high, from the alveolar edge to that which bounds the nostril below. The greater part of the outer surface of the bone is smooth; but towards its anterior end it becomes rugged and pitted, and seems to have been produced downwards and forwards into a short beak-like process.

Upwards and backwards the same region of the præmaxilla passes into its anterior ascending process, which is 0·7 inch long, and becomes very slender above. Each uniting by harmonia, but not ankylosing, with its fellow, the two lie between, and separate, the inner edges of the nasal bones for a certain distance. Behind the nasal aperture the præmaxilla rises into its posterior process, which is about as long as the anterior, but has a much greater breadth. The posterior margin of the process, and of the body of the bone below it, is concave, rounded, and must have been quite loosely united with the anterior edge of the maxilla.

Five teeth with lanceolate acuminated crowns (fig. 3) lie close together in the præmaxilla, occupying a distance of 0·55 inch from its posterior end; but the alveolar margin of the "beak," which is continued in front of this, presents no indication of the presence of teeth. The maxilla is imperfect behind. So much of it as remains measures 1·5 inch in length, and rather more than half an inch in depth, posteriorly, where it is deepest. It bears ten teeth. The crowns of the anterior eight are well preserved; but the two hindermost are broken, only the section of the fang of the last being visible. The anterior four teeth are rather smaller than the others; and this is especially true of the first tooth. The anterior edge of the crown of each of these teeth slightly overlaps the posterior edge of the crown of its predecessor. In the fifth, sixth, seventh, and eighth teeth, the overlap seems to have taken place in the opposite direction, the hinder edge of each tooth projecting a little beyond the anterior edge of its successor. The teeth are imbedded by single fangs, and, judging from the hindermost, are lodged in distinct alveoli. In unworn teeth the summit of the crown is sharp, and has a curved contour, which is more convex downwards in the anterior than in the posterior teeth. The free edge of the crown presents no trace of the serrations which are so characteristic of the teeth of *Iguanodon*; but it is sinuated by the terminations of sundry strong ridges of the enamel (fig. 2), which start from a sort of cingulum at the junction of the crown with the fang and, somewhat diverging and diminishing in thickness, traverse the outer surface of the crown. The cingulum is sharply angulated upwards in the three anterior teeth; but the angle becomes obtuse in the hinder teeth. The principal enamel ridge proceeds from the open angle of the cingulum, or a little behind it, to the crown. Secondary ridges of less prominence, which may not reach the cingulum, subdivide the spaces on each side of the principal ridge; and between them there are still shorter tertiary ridges, which do not extend more than halfway from the free edge towards the fang of the tooth. The sixth tooth is that the crown of which is most worn down, the other teeth being to all appearance less worn as they are further from it. The planes of the worn surface of the crowns, as in *Iguanodon*, cut the axis of the tooth at an acute angle, looking inwards as well as downwards. The outer contours of the teeth are convex from above downwards, but hardly so much so as in *Iguanodon*.

At first sight, these teeth look very similar to those of *Iguanodon*;

and I was almost disposed to admit their identity with those of the latter genus, after the rapid examination which was alone possible at the meeting of the British Association at Norwich. A more critical comparison, however, has convinced me that the teeth of this reptile are perfectly distinct from those of the great Wealden Dinosaurian.

A large postfrontal separates the orbit from the temporal fossa, and appears to have united with the jugal, of which only an impression remains. A præfrontal is distinguishable at the upper and anterior part of the orbit. Beneath and behind it, lies a broken but very large and curiously curved lacrymal (*La*), which is deeply grooved upon its outer surface, the outer and posterior lip of the groove being much shorter than the inner and anterior lip. An ascending process of the maxilla seems to have articulated with the posterior and inferior end of the lacrymal. The anterior margin of this lacrymal process of the maxilla, the superior margin of the body of the maxilla in front of it, and the posterior margin of that broad nasal process of the maxilla which ascends behind the præmaxilla are all smooth, and evidently natural, free edges. Hence there must have been a considerable prælacrymal vacuity (*a*) in the walls of the face. The postfrontal sends a long process backwards, outside an anterior prolongation of the squamosal, the two combining to form the supratemporal zygoma. An impression on the matrix proves that there was a strong infratemporal zygoma formed by the jugal and quadrato-jugal; and on the left side the under part of this is visible. Remains of large sclerotic plates lie in the orbit. The hinder face of the distal half of the quadrate bone is displayed upon the left side (fig. 4, *Qu*). It is a very strong bone, the articular surface of the condyle measuring not less than half an inch from side to side.

The occipital face of the skull is much injured, but it was evidently directed almost perpendicularly to the upper face. The left parotic process is well displayed, and is proportionally large, being half an inch long and 0·3 inch wide. The base of the skull exhibits the injured basioccipital region, and the more perfect basisphenoid, which possesses two strong, divergent, basipterygoid processes. Against the outer ends of these the strong pterygoid bones abut. These are not at all unlike the corresponding bones in an *Iguana*. The central part, or body, of the bone is very strong; and it sends backwards and outwards a deep, laterally compressed plate, which abuts against the inner side of the quadrate bone. The body of the pterygoid bone is very strong, and produced vertically. Anteriorly and externally it becomes connected, by a transverse bone, with the maxilla. A small palatine bone is seen on the left side in front of the pterygoid. The pterygoid is, in many respects, like that bone in the existing *Iguanæ*; and this specimen shows very clearly that the *Dinosauria* had a Lacertilian and not a Crocodilian arrangement of the pterygoid and palatine bones. Only the right ramus of the mandible can be seen; and the symphysial end of that is broken away. But what remains is nearly in place, and shows that the angular process was relatively small, while the coronoid rises abruptly, in front of the articular surface, to the height of an

inch from the inferior edge of the ramus. From the coronoid process, the height diminishes with a tolerably rapid sweep (but not so rapid as in *Iguanodon*), and the broken end, 2·5 inches from the articular surface, is only 0·5 inch high. The mandibular teeth are completely hidden.

The centrum of a vertebra (fig. 1, *c*), which lies on the outer side of the ramus of the mandible, is 0·6 inch long, and the exposed articular end, which is very slightly concave, is 0·45 inch high by 0·4 inch wide. The middle of the centrum is narrower than the ends, and the whole centrum, seen sideways, looks remarkably flat and wall-sided. Any processes the vertebra possessed must have come off from the neural arch, and therefore there can be no doubt that this is a dorsal vertebra. Thus the length of the skull appears to have equalled that of about six dorsal vertebræ.

The teeth of this reptile leave no doubt as to its distinctness from *Iguanodon*; and, as I shall immediately bring forward evidence to prove, that difference is generic. I propose, therefore, to name it *Hypsilophodon* Foxii*.

In the British Museum there is a considerable portion of the skeleton of a reptile, imbedded in the two portions of a slab of Wealden sandstone, of which the one was formerly the property of Dr. Mantell and the other of Dr. Bowerbank, but which are now happily reunited. This skeleton has been described and figured by Professor Owen, in the publications of the Palæontographical Society, as that of a young *Iguanodon Mantelli*.

The fossil is stated to have been discovered "in the Wealden formation, about one hundred yards west of Cowleaze Chine, on the north-west coast of the Isle of Wight, in the year 1849;" and the Rev. Mr. Fox informs me that it was found in the same bed as his specimen of *Hypsilophodon*, a stratum which, up to the present time, has yielded no remains of *Iguanodon*.

Two years ago, namely in December 1867, I became convinced, by the evidence of the British-Museum specimen itself, that it could not possibly be *Iguanodon*. The form and proportions of the vertebræ, especially of the caudal vertebræ, were quite different; the femur, with many points of similarity, exhibited sundry remarkable differences; and, most important of all, the metatarsus proved the Cowleaze reptile to have, at fewest, four well-developed toes. Again, if, as the describer of the fossil imagined, the bones numbered 66 and 67 (Palæontographical Society, "Fossil Reptilia of the Wealden," tab. i.) are the right tibia and fibula, any identification with *Iguanodon* is out of the question, inasmuch as the leg would be much longer than the femur, while in *Iguanodon*, as the Maidstone specimen proves, it is shorter. Thus I made sure that the Cowleaze fossil represented a new genus; and, under the circumstances, the probability that it once formed part of the body of a *Hypsilophodon* is obviously very great. The fortunate preservation of the centrum of a single dorsal vertebra, along with the skull, greatly strengthens this already strong presumption. On compari-

* *Hypsilophus* is a name proposed by Fitzinger for certain Iguanas.

son with a vertebra from the anterior dorsal region of the specimen in the British Museum, I can find absolutely no difference, except that the vertebra in Mr. Fox's specimen is a shade smaller. The centra of the anterior dorsals in the former are rather less than 0·7 inch long; in the latter the measurement is 0·63 inch. The difference, therefore, is not more than $\frac{1}{20}$ of an inch. The vertebral column of the specimen in the British Museum has been particularly described by Professor Owen; but the caudal vertebræ have been much more completely cleared of the matrix since his memoir was written. The remains of eighteen vertebræ may be made out, in consecutive series, from the cervical to the posterior dorsal region; and the position of the ilium is such, that there can hardly have been more than two or three vertebræ between the hindermost of those which are visible and the sacrum. In the most anterior of these eighteen vertebræ (which may thus, probably, be the twentieth, or twenty-first, from the sacrum) the anterior, escutcheon-shaped, face of the centrum is distinctly convex from side to side, and slightly concave from above downwards, while the posterior face is markedly concave. The neuro-central suture passes through the capitular process; and the tubercular process springs much higher up upon the arch, beneath the præzygapophysis, the articular face of which looks as much inwards as upwards*. It is only the hindermost, or ninth, cervical vertebra of a crocodile which presents these characters. In all the more anterior cervicals the neuro-central suture passes above the process for the capitulum of the rib; I therefore conclude that, in all probability, the anterior vertebra of the *Hypsilophodon* skeleton belonged to the posterior region of the neck. I should think it very possible that there may have been seven, or eight, cervical vertebræ between the most anterior of those preserved and the head. In this case, the light head, borne upon the relatively long neck, will have given the fore quarters of *Hypsilophodon* much resemblance to those of a Monitor.

Professor Owen concludes, from certain striæ on the articular surfaces of the vertebral centra, that "the vertebral bodies of the Iguanodon *were coarticulated by means of an intervertebral ligament, as in the class Mammalia*;" and he emphasizes this conclusion by putting it in italics. I have little doubt that the vertebral centra of *Hypsilophodon* were so connected; but so are those of a Crocodile, and the fact does not constitute the slightest evidence in favour of the mammalian affinities of the *Dinosauria*.

In resuming my study of the specimen of *Hypsilophodon* in the British Museum, for the purposes of the present paper, the difficulty which had previously presented itself of reconciling what could be seen of the structure of the bones numbered 66 and 67 (tab. i. 'Fossil Reptilia of the Wealden Formation') with what is known of the tibia and fibula of the *Dinosauria* returned very strongly

* The two following vertebræ have similar characters; but the articular surface of the sixth appears to be slightly concave in front as well as behind. In this vertebra the transverse process springs from the arch, far above the neurocentral suture.

to my mind. On the other hand, my present knowledge of the strange characters of the pelvis in the Dinosaurian reptiles led me to suspect that those bones might prove to be the pubis and ischium *in situ,* and in their natural connexion with the right ilium, the posterior part of which bone (numbered 62 in the plate cited) was conspicuously visible. Careful search revealed the anterior end of the bone overlying the arch of the posterior vertebræ of the dorsal series.

With the permission of the Keeper of the fossil collection, therefore, the specimen was subjected to a further careful removal of the matrix in the requisite directions. The result has been the complete verification of my conjecture, and the specimen now affords a view of the ventral elements of the pelvis in their natural relations (Pl. II.).

The middle part of the right ilium is covered, and, seemingly, a little crushed in, by the left foot. But its broad postacetabular portion (*b*), and its relatively narrow and pointed præacetabular part (*a*) are completely exposed. I suspect that the ilium is broken in the middle, and, as a consequence, that the distance from the posterior to the anterior ends of the visible parts of the bone (6·6 inch) is somewhat greater than it should be. Hence the acetabulum probably appears to be longer than it naturally is. The postacetabular process (*c*), which should articulate with the ischium, is swollen and thick, but thins off, above and behind, into a thin vertical plate, the posterior curved margin of which is broad and turned in, like a narrow shelf. The præacetabular prolongation is slender, and its broken narrow end (*a*) rests on the arch of the seventeenth vertebra.

The anterior boundary of the acetabulum is formed by a broad, somewhat flattened, facet of bone (*d*), which looks backwards and a little outwards. The osseous mass, of which this forms the posterior aspect, rapidly narrows forwards, and is prolonged above into a slender ridge, or process, with a free rounded end (*a*). In front, it has a sinuated free edge; anteriorly and below, it is continued into a slender rod-like pubis (*Pb*), between six and seven inches long, which passes downwards and backwards parallel with the ischium. On the outer surface, in front of the lower part of the articular surface, lies an oval foramen (*e*). The posterior edge of the bone is concave and free. Posteriorly and below, it ends in a broad thin prolongation, which passes backwards, internal to the ischium. The part of the bone which bears the facet answers very well to the præacetabular process of the ilium of *Megalosaurus* and of *Thecodontosaurus*. The perforation is indeed somewhat like that which is so generally found in the pubis of Lizards; but, on a future occasion, I hope to be able to show its analogue in the ilium of an undoubted Dinosaurian. If this part of the acetabular wall answers, as I believe it does, to the descending præacetabular process of the ilium, all trace of the suture between it and the pubis has disappeared.

The right ischium (*Is*) lies in undisturbed relation with the pubis. Its acetabular end has a free superior concave edge which bounds the acetabulum below, a broad thin anterior process which over-

laps and is firmly united with the pubis, and a posterior process which becomes very thick behind and articulated with the post-acetabular process of the ilium. The shaft of the bone is flattened laterally, and has a thick and rounded posterior edge. Anteriorly it is thinner, and at 2·75 inch from the acetabulum it is produced into a broad and long decurrent process, the free edge of which overlaps the pubis. Such a process is very generally developed in birds. Beyond this process the ischium widens out, and seems to terminate in a spatulate free end, like that of the corresponding part of the ischium in *Megalosaurus* and *Iguanodon*. This spatulate extremity is broken away from the right ischium, but remains on the other side (*Is'*). And their relative position leads to the belief that the two bones united in a ventral symphysis. The long diameters of the ischia and pubes are parallel, and they are directed downwards and backwards in such a manner as to make an obtuse angle with the anterior half of the long diameter of the ilium. *Hypsilophodon* is the first reptile in which this disposition of the ischium and pubis has been observed.

Eleven caudal vertebræ in series, with a rudiment of a twelfth at the posterior end, and another which lies on one side of these, all belonging to the anterior part of the tail, are represented in the plate cited, but they have been worked out much further since it was published. The characters of some of the vertebræ are very well shown. For example, the third from the anterior end in the series of eleven now exposed, is 2 inches high from the lower edge of the centrum to the summit of the spine (Pl. I. figs. 6 & 7). The centrum is 0·8 inch long, while its articular faces are 0·6 inch high. The transverse measurements of the articular faces of the centrum cannot be ascertained in this vertebra; but that of the posterior face of the vertebra which lies by itself is 0·5, the length of the vertebra being 0·7 inch. The spine of the "third" vertebra measures, from the postzygapophysis to its truncated extremity, 0·85 inch, and 0·36 inch from before backwards; the spines of all the caudal vertebræ are slightly inclined backwards. The root of a transverse process (or caudal rib), 0·36 inch long, stands out at right angles from the upper part of the side of the centrum, its posterior edge inclining forwards. The under face of the centrum is concave from before backwards, and presents a narrow and flattened surface, traversed by a longitudinal groove. The zygapophyses are long, and the planes of their articular faces are almost vertical. The obliquely truncated surfaces for the articulation of the chevron bones at the anterior and posterior ends of the ventral face of each centrum are well marked. No chevron bone is attached to the vertebra under consideration; but several lie, one on the top of the other, beneath the fifth to the eighth vertebra of the caudal series. The best-preserved of these is 1·75 inch long, 0·38 inch wide at the vertebral end (Pl. I. fig. 8). The vertebral ends of the forks of the chevron bones are expanded and ankylosed together in the manner characteristic of the *Dinosauria*.

The length of the left femur is 5·7 inches, or rather less than the

length of the hinder eight of the series of dorsal vertebræ. The extreme breadth of the distal end is 1·45 inch, the extreme breadth of the proximal end, from the inner surface of the articular head to the outer surface of the shaft, 1·73 inch. The femur is therefore slightly shorter in proportion to the length of the dorsal vertebræ than in *Iguanodon.* The faces of the inner trochanter look much more directly inwards and outwards, and the whole process has a different shape from that of *Iguanodon.* There is no pit above the inner trochanter, such as exists in *Iguanodon*; and the deep intercondyloid groove, on the anterior face of the distal end, which is so characteristic of *Iguanodon,* is wanting.

The remains of what I take to be the right fibula and tibia are seen in front of the pelvis. What remains of the fibula is 4 inches long, and shows the proximal end and moiety of the shaft tolerably entire. The former measures 0·7 inch from before backwards, but not more than 0·2 inch in width. The anterior edge of the shaft is turned towards the eye. An impression on the matrix is continued in the line of direction of the bone, and suggests that it was altogether about five inches long, and that its distal end had a width of 0·4 inch. In *Iguanodon,* the length of the tibia is to that of the femur as 31 to 33, and the fibula is somewhat shorter than the tibia. If *Hypsilophodon* followed the proportion of *Iguanodon,* the tibia should be 5·35 inches long, and the fibula rather more than five inches.

On reference to the memoir which I have cited, it will be observed that my interpretation of the bones described is very different from that adopted by Prof. Owen (p. 2). He terms the femur (65) "the right femur," and states that "the bones of the right hind leg are almost completed when the blocks containing their opposite ends are brought into juxtaposition." But the most cursory inspection is sufficient to show that the femur belongs to the left side, and, as I have proved, the so-called right tibia and fibula (66 and 67) are really the two ischia and the pubes.

I find myself compelled to dissent as widely from Prof. Owen's view of what he terms "the principal bones of the right hind foot." I have no sort of doubt it is the left hind foot. For there are two bones belonging to the distal tarsal series in their natural relation with one another, and with two, if not three, metatarsal bones. These bones are obviously the homologues of those which exist in *Scelidosaurus* and in the *Crocodilia,* and which lie on the outer side of the foot. The metatarsals which are connected with these bones, therefore, must needs belong to the outer, or fibular, digits; and, as the dorsal surface of the metatarsus is turned towards the eye, the foot can only be that of the left limb. In the proximal row of the tarsus lie a calcaneum (which seems to have a process as in Crocodiles) and an astragalus, with a convex distal face and seemingly flattened from above downwards. Whether it has an ascending process cannot be distinctly made out. The proximal and the distal series of bones are dislocated, and what looks like the end of the tibia is seen between and below them. The metatarsals of the first, second, and

third digits are quite distinct; but the distal end is entire only in the first, or that of the hallux, which measures 1·85 inch in length. It has a pulley-shaped articular surface, and is 0·5 inch wide. The shaft of the bone is greatly compressed from side to side, as in *Scelidosaurus*. The second and third metatarsals are much broader and stouter, with flattened superior faces. They also seem to have been longer than the first. The fourth metatarsal looks, at first, as if it were much wider than the other; but, on close examination, I think I can trace a line of matrix separating a true fourth metatarsal, of about the same size as the others, from a slender fifth metatarsal. A basal phalanx, which seems to have belonged to the middle digit, is 1 inch long, 0·6 inch wide at the proximal, and 0·35 inch at the distal end. The pes of *Hypsilophodon*, thus, was either tetradactyle or pentadactyle.

The length of the trunk and tail of *Hypsilophodon* was probably about 4½ feet; and, in all likelihood, it was mainly herbivorous.

[For description of Plates I. & II. see p. 50.]

---

4. Further Evidence *of the* Affinity *between the* Dinosaurian Reptiles *and* Birds. By T. H. Huxley, LL.D., F.R.S., President of the Society.

On my way to Birmingham, in October 1867, I chanced to meet with Prof. Phillips; and mentioning some palæontological inquiries, chiefly relating to the Ichthyosauria (with which I then happened to be occupied), he very kindly urged me, as I returned to London, to pay a visit to the collection under his charge in the University Museum at Oxford. I did so; but as we were traversing the museum towards the Ichthyosaurian cases, we stopped at that containing the Megalosaurian remains, and I may say with Francesca—

"Quel giorno più non vi leggemmo avanti."

It is indeed a wonderful collection, ample enough to occupy the working hours of many a day; and it was particularly attractive to me, as some difficulties in the organization of *Megalosaurus* and its allies had long perplexed me.

As Prof. Phillips directed my attention to one after the other of the precious relics, my eye was suddenly caught by what I had never before seen, namely the complete pectoral arch of the great reptile, consisting of a scapula and a coracoid ankylosed together. Here was a tangle at once unravelled. The coracoid was totally different from the bone described by Cuvier, and by all subsequent anatomists, under that name. What then was the latter bone? Clearly, if it did not belong to the shoulder-girdle it must form a part of the pelvis; and, in the pelvis, the ilium at once suggested itself as the only possible homologue. Comparison with skeletons of reptiles and of birds, close at hand, showed it to be not only an ilium, but an ilium which, though peculiar in its form and proportions, was eminently ornithic in its chief peculiarities.

Next came the question of the nature of the so-called "clavicle." The determination of the structure of the shoulder-girdle threw open the homology of this bone, which clearly could not be a clavicle, whatever else it might be. The alternative position once more lay in the pelvis, and this time between the ischium and the pubis; and as the ilium was bird-like, might not the ischium, or pubis, be also expected to be ornithic in form? At any rate the bone answered remarkably well to the ischium of one of the *Ratitæ*.

Resemblances to the structures found in some birds had already been noted by Prof. Owen * in the sacrum of the *Dinosauria*; but these specially ornithic peculiarities of the pelvic girdle had not been indicated by any anatomist, and opened up a very interesting field of inquiry. To this I devoted all my disposable leisure during the winter of 1867–8, occupying myself chiefly with a critical examination of the materials in the British Museum in order to ascertain how far the peculiarities of *Megalosaurus* were common to the *Dinosauria* in general. As I knew that Prof. Phillips had devoted a great deal of time and thought to the collection which he has done so much to form, I begged him to furnish me with a statement of the results at which he had arrived before my visit; and in the commencement of 1868 he favoured me with the following letter:—

"Oxford, 1st January, 1868.

"My dear Huxley.—I must no longer delay to send you a notice of some specimens of Megalosaurian bones in this Museum, and of the doubts which frequent examination of them had raised in my mind touching the true composition of the skeleton. Since I had the opportunity of speaking to you on this matter, with the specimens before us, you have made so much progress toward replacing doubts by decisions, that, in truth, there is little now to be said which can appear to you either new or important. Still it will be a pleasure to me to recall the process by which I was led to form a quite different idea of *Megalosaurus* from that which I had derived from Cuvier and Buckland—the great early and skilful explorers in this field. When I came to reside in Oxford, and to handle the noble collection of Dr. Buckland, I was speedily satisfied that only two groups of reptilian bones were *frequent* at Stonesfield and in the contemporaneous (geologically speaking) Oolitic beds of the vicinity, viz. *Megalosaurus* and *Teleosaurus*. To these must be added, as usually of somewhat later date, *Cetiosaurus* of Owen, and, still later, for the most part, *Steneosaurus*. *Teleosaurus* and *Steneosaurus* require *scrutiny* to be differentiated; the bones of *Cetiosaurus* in this collection are more easily separated from those of *Megalosaurus*; but there are not many homologous bones of these two reptiles in our collection, rich as it really is. I mention these things chiefly to satisfy you that, *exceptis excipiendis*, the large case which you

* Prof. Owen evidently attached no weight to the fact as indicating any affinity of the *Dinosauria* with birds, as in his 'Report on British Fossil Reptiles,' 1861, p. 102, he says that "the Reptilian type of structure makes the nearest approach to Mammals in the *Dinosauria*."

saw filled with the reliquiæ of the great land Saurian contained no other than his personal remains.

"When the Stonesfield fossils came before me for lectures to a practical class, it was often my desire to present a sketch of the skeleton for comparison with that of a crocodile, and a pleasure to me to employ in this way such knowledge of the osteology of reptiles as a few dissections, now thirty or forty years ago, of each great reptilian group had fixed in my mind. For making these drawings on a large scale I was obliged to examine and consider several times the great bone called by Cuvier 'coracoid,' and to *complete* it by adding, after the pattern of *Varanus*, the extensions toward the sternum. When this was done, the magnitude of the thoracic region became such as to terrify me, and I looked eagerly through the collection for anything to relieve my alarm. Not being able to find any trace of sternal or episternal bones, I examined the curiously bent bone commonly referred to clavicle, and perceived that *it* was of the same order of magnitude. Next a set of spatulate bones, in fragments, came under my notice, and I speedily decided, *ex necessitate*, these to be scapulæ*. When completely restored they presented long flattened bones, concave on one broad face, convex on the other. I know no scapulæ like them except those of birds; and among birds none appeared to fit so well in the comparison as *Apteryx*. Then I reflected—a scapula like this, how could it belong to a coracoid like that? Examining for this purpose the humeral extremity of the bone, and collecting all the examples, I found it was composed of two elements ossified together, these elements concurring on one edge to form an articular cavity. Of these elements the broader and shorter one, which extended toward the sternum, was coracoidian in form, and perforated in each of four specimens. If, as appeared now to be the case, this was the coracoid, surely the great heavy bone so long called by that name was a pelvic bone, and the restoration of the skeleton must proceed on an entirely new basis.

"It soon became evident that the bone so long regarded as a clavicle must be removed from the place it had occupied, with the so-called coracoid, to which it was proportioned. It could not be attached to the now ascertained scapulo-coracoidian arch. It seemed calumnious to assign such a bandy-legged bone to either the radial or tibial alliance—besides that there could be presented a better claimant for the honours of the fibula, if not of radius or ulna. What could this bone be? In this state of uncertainty you found me, and helped me to a clearer view of the whole case now opening. I showed you the long bones which seemed to me to have the best claim to be regarded as of the fore limb, remarking that every thing seemed to indicate the fore limb of *Megalosaurus* to have been comparatively light and applicable,—not merely a strong support to a heavy body, as was thought to be the case when the huge

* In his "Notice of *Megalosaurus*" (Brit. Assoc. Reports, 1841, p. 108) Professor Owen says, "The scapula is a thin, slightly bent plate, of equal breadth, except where it is expanded and thickened towards the humeral end, but thinning off again towards the articular margin."

oval bone was called a coracoid. I pointed to an incomplete bone which you quickly decided to be humeral—rather a small bone as compared with the femur.

"Turning now to the hinder extremity, it was easy to see that as the small glenoid cavity formed in the scapular and coracoidian bone was fitted for a small humerus, so the great hollow in the heavy, arched pelvic bone was adapted to the large head of the well-known femur, 3 feet long. But to name this great pelvic bone was a difficulty with me. I was under the impression that its broad, smoothly expanded surface might be best compared with that of an ischium * or pubis, and that this would be more suited to the broad depressed body (as I supposed it to be) of such a huge creature, than, by accepting it as an ilium, to admit the beast to have been narrow in the rear, like a bird, with the plane of the bone not much inclined from the vertical. The only points in favour of its being possibly an ilium were, first, its resemblance to that bone in birds, and specially in *Apteryx* (to which I confess I gave but little importance, as too unlikely to be accepted), and, secondly, marks apparently of bony attachment, on one face of the bone, such as might be left by the removal of cohering processes from the sacrum. To this I was reluctant to give weight for the same reason, viz. that it seemed to make *Megalosaurus* too 'sib' with primæval birds. In this state of mind you found me, and, to my surprise, took up *de novo*, and resolutely, to compare the bone with the pelvic arrangement of Ostrich and its congeners †. You also then seized upon the so-called "clavicle," and rapidly placed it in a probable manner to one of the tuberosities which project beyond the acetabular cavity, and called it an ischial or else a pubic bone, of struthious rather than lacertian analogy. Every observation which I have since been able to make goes to confirm this result, and the corollary from it, viz. a decided ornithic alliance of the pelvic, as we already found in the sternal, arrangement. Perhaps in the same direction may be cited the distinctly tubular character of the limb bones, which I have not perceived as yet in *Cetiosaurus*, though it may perhaps be found to be the case, and I think it will be.

"As you are now engaged in working out the true affinities of this uncommon creature, I propose to send you careful drawings of our most characteristic specimens, and will now only request your attention to one or two things which have occurred to my observation.

"These are two forms of the great pelvic (ilial) bone—the well-

* In his "Report on British Reptiles" (British Association Reports, vol. i. p. 109), Prof. Owen describes "a subcompressed three-sided bone, flattened and slightly expanded at one end, thickened and more suddenly extended transversely at the opposite end, which formed part of a large cotyloid cavity," as most likely an ischium. "Length 18 inches, breadth at the middle of the shaft 5 inches, at its articular end 9 inches, the thickness of this end 4 inches." Where is this bone preserved?

† It appears that Buckland had suggested to Cuvier, but unsuccessfully, what now appears to be the right view; for we read, "Toutefois je ne puis guère douter que ce ne soit un coracoïdien de Saurien: il ressemble beaucoup moins à leur os des îles, auquel M. Buckland l'a comparé" (Oss. Foss. v. pl. 2, p. 346).

known ordinary form, which occurs in several examples, and another, in one quite young. The difference is very considerable, too great, I suppose, to be explained as a mark of age.

"There are two forms of scapula, both very large: the largest (one example) is separate from the coracoid; the others (several) are joined to the coracoid by synostosis. You will see the differences in the drawings. I am disposed to admit the larger specimens as belonging to *Cetiosaurus*, of which one huge femur (*Cetiosaurus giganteus*, Owen) was found in a deposit not much differing in age, at Gibraltar, north of Oxford.

"We have several specimens of metatarsal bones from Stonesfield—Megalosaurian no doubt. Lately there came to hand three metatarsals from the Kimmeridge clay of Swindon, which appear also to be of the same reptile. These were in apposition, cemented by a thick crust of selenitic crystals. These have now been removed, and the bones appear clear.

"It seems to me that these three bones were all that were in the metatarsus, and that the creature was tridactyle; but of course there may be reason not to trust too much to one case for proof of a negative. Still that seems to me the probable inference. As we have plenty of information about the femur, tibia (fibula?), metatarsals, and claw-bone, the reconstruction of the animal seems now practicable. But we want in this museum information as to cervical* and anterior dorsal vertebræ, and the central part of the sternal arrangements: of ribs we have sufficient examples, from anterior very short bicipital ribs, to very long arched widely bicipital ribs about the middle of the body, or, rather, a little before the middle. The *Marsupialia* do not appear to me to offer any special resemblances to any of the Megalosaurian bones. Among reptiles Crocodiles furnish the most analogous forms, among birds the *Struthionidæ*.

"Wishing you well through the Deinosaurians,

"Believe me, ever yours truly,

"John Phillips."

On the 7th of February, 1868, I published the chief results of the studies to which Prof. Phillips gives his benediction, in a lecture "On the Animals which are most nearly intermediate between Birds and Reptiles," delivered at the Royal Institution, and subsequently published in the 'Proceedings' of that body, and also, with the addition of sundry illustrations, in the 'Popular Science Review.' But in this lecture I drew my illustration of Dinosaurian structure almost wholly from *Iguanodon*. My reason for this was that *Iguanodon* was the only typical *Dinosaurian* of which the remains of the greater part of the body of a single specimen were associated together, while, at the same time, detached bones, all the peculiarities of which can be clearly made out, are numerous.

The conclusions at which I had at that time arrived are thus enunciated:—

* Professor Phillips has now (January 1870) obtained a cervial vertebra. It suggests a smaller head than was calculated from the known portion of the lower jaw.

"The *Dinosauria*, a group of extinct reptiles, containing the genera *Iguanodon, Hadrosaurus, Megalosaurus, Poikilopleuron, Scelidosaurus, Plateosaurus*, &c., which occur throughout the whole series of the Mesozoic rocks, and are for the most part of gigantic size, appear to me to furnish the required conditions.

"In none of these animals are the skull or the cervical region of the vertebral column completely known, while the sternum and the manus have not yet been obtained in any of the genera. In none has any trace of a clavicle been observed.

"With regard to the characters which have been positively determined, it has been ascertained that:—

"1. From four to six vertebræ enter into the composition of the sacrum, and become connected with the ilia in a manner which is partly ornithic, partly reptilian.

"2. The ilia are prolonged forwards, in front of the acetabulum, as well as behind it; and the resemblance to the bird's ilium thus produced is greatly increased by the widely arched form of the acetabular margin of the bone, and the extensive perforation of the floor of the actabulum. The other two components of the *os innominatum* have not been observed actually in place; indeed, only one of them is known at all, but that one is exceedingly remarkable from its strongly ornithic character. It is the bone which has been called 'clavicle' in *Megalosaurus* and *Iguanodon* by Cuvier and his successors, though the sagacious Buckland had hinted its real nature *. But these bones are not in the least like the clavicles of any known animal, while they are extremely similar to the ischia of such a bird as an ostrich; and in the only instance in which they have been found in tolerably undisturbed relation with other parts of the skeleton, namely, in the Maidstone *Iguanodon*, they lie, one upon each side of the body, close to the ilia. I hold it to be certain that these bones belong to the pelvis, and not to the shoulder-girdle, and I think it probable that they are ischia; but I do not deny that they may be pubes.

* The so-called "coracoid" of *Megalosaurus* is the ilium, I am indebted to Prof. Phillips, and to the splendid collection of Megalosaurian remains which he has formed at Oxford, for most important evidence touching this reptile.

[I do not know how it came about that I have here confused Dr. Buckland's suggestions with one another. In his memoir "On the *Megalosaurus*" (Tr. Geol. Soc. 2nd ser. vol. ii. p. 396), Dr. Buckland says:—

"The bone represented in fig. 3 is the outside view of the ilium, slightly concave. The inner surface is slightly convex, and shows marks of articulation with the sacrum."

The bone in question is that of which Cuvier makes the remark quoted by Prof. Phillips.

All subsequent writers have followed Cuvier's determination, which was wrong, and ignored Buckland's, which was not only quite right, but the key to a great deal that is most important in Dinosaurian organization. The so-called "clavicle" was so named by Buckland himself. Cuvier hesitates to recognize it as such, inclining to the belief that it may be the fibula. According to Prof. Owen the presence of this clavicle is one of the chief features of the *Dinosauria*. "The chief marks of difference from the Crocodile structure of the scapular arch and of resemblance to the Lacertian type is the presence of a distinct pair of clavicles."—Fossil Reptilia of the Wealden Formation, p. 33.]

"4. The head of the femur is set on at right angles to the shaft of the bone, so that the axis of the thigh-bone must have been parallel with the middle vertical plane of the body, as in birds.

"5. The posterior surface of the external condyle of the femur presents a strong crest, which passes between the head of the fibula and the tibia, as in birds. There is only a rudiment of this structure in other reptiles.

"6. The tibia has a great anterior or 'procnemial' crest, convex on the inner, and concave on the outer side. Nothing comparable to this exists in other reptiles; but a correspondingly developed crest exists in the great majority of birds, especially such as have great walking- or swimming-powers.

"7. The lower extremity of the fibula is much smaller than the other; it is, proportionally, a more slender bone than in other reptiles. In birds the distal end of the fibula thins away to a point, and it is a still more slender bone.

"8. *Scelidosaurus* has four complete toes, but there is a rudiment of a fifth metatarsal. The third, or middle, toe is the largest, and the metatarsal of the hallux is much smaller at its proximal than at its distal end. *Iguanodon* has three large toes, of which the middle is the longest. The slender proximal end of a first metatarsal has been found adherent to the inner face of the second, so that if the hallux was completely developed it was probably very small. No rudiment of the outer toe has been observed.

"It is clear, from the manner in which the three principal metatarsals articulate together, that they were very intimately and firmly united, and that a sufficient base for the support of the body was afforded by the spreading out of the phalangeal regions of the toes.

"From the great difference in size between the fore and hind limbs, Mantell and, more recently, Leidy have concluded that the *Dinosauria* (at least *Iguanodon* and *Hadrosaurus*) may have supported themselves for a longer or shorter period upon their hind legs. But the discovery made in the Weald by Mr. Beckles, of traces of large, three-toed foot-prints, of such a size and at such a distance apart that it is difficult to believe they can have been made by any thing but an *Iguanodon*, lead to the supposition that this vast reptile, and perhaps others of its family, must have walked, temporarily, or permanently, upon its hind legs.

"However this may be, there can be no doubt that the hind quarters of the *Dinosauria* wonderfully approached those of birds in their general structure, and, therefore, that these extinct reptiles were more closely allied to birds than any which now live"*.

There is one part of the organization of the *Dinosauria* which is not mentioned in this enunciation, because I did not at that time see its bearing upon the problem under discussion, I mean the very singular structure of the distal moiety of the tibia.

It took me a great deal of trouble to comprehend the structure of

* Proceedings of the Royal Institution of Great Britain. Friday, Feb. 7. 1868.

this bone, the extant descriptions being very imperfect, and sometimes based upon bones which have been broken and put together the wrong way by the mender. In the British-Museum collection the only thoroughly trustworthy *Iguanodon* tibia I can find is the small one numbered 36,403. It has been broken into several pieces; but they are very well fitted together, and the bone is not at all distorted. A second tibia of *Iguanodon*, with a very good proximal end, is numbered 28,669. The distal end of the Megalosaurian tibia (No. 31,809), which has been figured, is imperfect; but there was a tibia of *Megalosaurus* in the collection, the distal end of which was still inserted in its matrix; and, at my request, it was very carefully worked out. This tibia is the most perfect I have seen.

Its proximal end is produced into a great cnemial crest, which is concave on its outer, convex on its inner side. But when the backs of the condyles rest upon a plane surface, the outer edge of the crest does not project beyond the outer side of the bone. The inner and outer condyles of the proximal end are not very unequal, though the outer is the smaller. On the outer side of the proximal end of the bone there is a strong longitudinal ridge for the attachment of the fibula. The shaft of the bone is somewhat flattened from before backwards, and the distal end is still more flattened and expanded. Moreover the direction of its faces is quite different from that of the principal faces of the proximal end of the bone. These look inwards and outwards, supposing the condyle to rest upon a posterior plane surface. But the faces of the distal moiety of the tibia look forwards and outwards, and backwards and inwards, the plane of the distal end of the bone being nearly at right angles to that of the proximal end. The antero-external face of the distal end presented a somewhat smooth surface, apparently for the articulation of a bone; and this surface was bounded above and internally by a sharply defined edge, which terminated the face of the shaft of the bone. This edge at first passed outwards and backwards, and was convex downwards; but having reached the middle of the surface of the bone, it turns upwards and is lost at about $\frac{1}{5}$ the length of the tibia from its distal end. The distal articular surface is wider internally than externally, and its external moiety projects further than the internal, so that its inferior contour is oblique and slightly sinuated.

The tibia of *Iguanodon* is similar in its general characters to that of *Megalosaurus*; but the two condyles at the proximal end are more unequal, and the great cnemial crest is bent over in such a manner as to project far beyond the outer side of the tibia when the posterior edges of the condyles rest upon a plane surface. There is a small facet just beneath the outer condyle, for the proximal end of the fibula; but no crest for that bone is developed from the outer face of the tibia. The distal half is not so flattened as in *Megalosaurus*, but more trihedral. Its plane is twisted in the same way in relation to the antero-posterior plane of the bone, as in *Megalosaurus*. The distal extremity is divided into a larger antero-internal, and

a smaller postero-external moiety. The former presents a convex articular surface, which looks obliquely downwards and outwards. The postero-external moiety is an irregularly concavo-convex surface, which projects suddenly and considerably beyond the level of the other.

Fig. 1. Fig. 2.

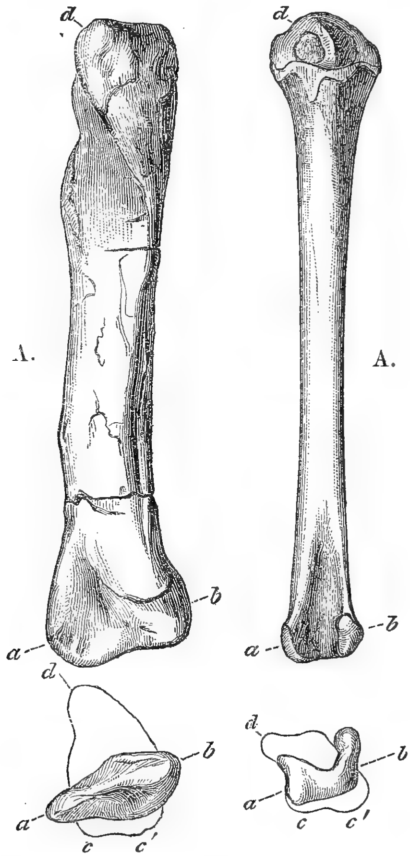


Fig. 1. A, the right tibia of *Megalosaurus*. The posterior margins of the articular condyles are supposed to be in the plane of the paper; *a–b*, a line traversing the median plane of the distal end of the bone; *d*, the summit of the cnemial crest. The strong fibular ridge is seen on the outer surface of the proximal third of the bone.

B, the distal extremity of the same bone projected upon the proximal end, which is drawn in outline. The letters as before, except *c* the outer and *c′* the inner condyle.

Fig. 2. A & B, corresponding views of the tibia of a young Fowl. The letters have the same signification.

The determination of the true form of the distal end of the tibia of *Megalosaurus* had some interesting consequences.

In the 'Ossemens Fossiles' (éd. 4^{me}, t. ix. p. 204, "Sauriens Fossiles"), the following passage occurs:—

"A lower portion of a tibia from Honfleur, with the astragalus, another bone of the tarsus, and a fragment which possibly belongs to the fibula indicate a hind foot of very extraordinary structure.

"To understand its nature, it is necessary to conceive that the leg to which these bones belonged was much compressed from side to side, so as to be sharp behind, like the tarsus of a duck, instead of being flattened from before backwards, like that of the Crocodiles, and still more that of the Monitors. Bearing this conception in mind, the bone *a a*, figs. 34–36, has some similarity in form to the astragalus of the Crocodile; but one sees that the calcaneum must have been altogether posterior and very small.

"The articular face of the tibia is 0·14 metre long; its greatest width (0·04) is towards its anterior fourth, which is acutely angulated; posteriorly, the inner edge is undulated. A curved crest ascends obliquely along the inner face of the tibia, and articulates with the ascending and compressed process of the astragalus. In consequence of its compression, the form of this astragalus is so curious that it mght be taken, at first sight, for the calcaneum of a mammal.

"Below, it presents a convex cylindrical surface; above, it is irregularly concave, to adjust itself to the sinuosities of the articular face of the tibia; from its inner edge, posteriorly, arises the compressed process of which I have spoken. The internal face is semilunar. Behind, it is truncated, presenting a little concave facet, which undoubtedly articulated with the calcaneum.

"The animal to which this lower part of a leg and this tarsus belonged cannot have been less than thirty-six feet long, supposing it to have nearly the same proportions as the Gavials. If it had the proportions of a Monitor, its length must have amounted to forty-six feet."

Now, on comparing the distal end of the tibia of *Megalosaurus* with that of Cuvier's Honfleur Saurian, it was quite obvious that the two were closely analogous, and that *Megalosaurus* must have had an astragalus very like that of the Honfleur reptile. Evidence confirmatory of this conclusion was derived from another quarter.

The 'Mémoires de la Société Linnéenne de Normandie' (tome vi. 1838) contain a very remarkable paper by M. Eudes Deslongchamps, "Sur le *Poikilopleuron Bucklandii*, grand Saurien Fossile intermédiaire entre les Crocodiles et les Lézards," discovered in a Caen-stone quarry. The remains of this animal indicate that it had a length of from 25 to 30 feet; and as teeth of *Megalosaurus Bucklandi* occur in the Caen stone, Deslongchamps is inclined to suspect that *Poikilopleuron* may be identical with *Megalosaurus*. Among the bones of his *Poikilopleuron*, Deslongchamps obtained two astragali, the resemblance of which to the bone described by Cuvier in the 'Ossemens Fossiles,' was exceedingly striking; and applying one of these bones to the end of a fragment which he had

previously considered to be a femur, he found that it was really the distal end of the tibia, corresponding in all its broad features with Cuvier's specimen from the Honfleur clays. Deslongchamps's very just appreciation of the close affinity between his *Poikilopleuron* and *Megalosaurus* would have been immensely fortified if he had been acquainted with the true structure of the distal end of the tibia of the latter reptile.

I had got thus far in February 1868, and it was on the strength of the facts just mentioned that I included *Poikilopleuron* in the list of the *Dinosauria*, in the lecture which has been cited. At that time, however, I had not seen the following notes by Prof. E. D. Cope, of Philadelphia, which are contained in the 'Proceedings of the Academy of Natural Sciences of Philadelphia,' for November 1866 and December 1867, and in the 'Proceedings of the Boston Natural History Society' for June 1869, and which constitute important additions to his previously published account of the American Megalosauroid *Lælaps*.

The similarity of Prof. Cope's general conclusions to my own, in his second note, render it necessary for me to point out that I could not possibly have known anything about them when my lecture was delivered, still less at the time when the letter from Prof. Phillips which I have cited, was written.

"E. D. Cope pointed out the anomalous relations existing between the tibia and the fibula in certain of the *Dinosauria*, as illustrated by the genus *Lælaps*. He remarked, the distal extremity of the tibia is transverse and much compressed, and does not exhibit any of the usual appearances of an articular surface, neither the reptilian condyle, nor a cotyloid cavity sufficient for an astragalus of the size necessary for an animal of such bulk. A bone presenting a broad hour-glass-faced articular surface was discovered with the other remains, and had puzzled the anatomists who had seen it. This piece exhibits along its whole posterior aspect two faces, which form a reentrant angle for a fixed articulation; this is found to have been applied to the extremity of the tibia exactly, and to have been fixed by strong articular ligaments. The medianly constricted condyle, presenting forwards and a little downwards, exhibits so little analogy with the astragalus, as to suggest other interpretations; and after a careful examination, it seems evidently the distal extremity of the fibula. This element furnishes a small articular surface at the knee, and fitting the tibia by the concavity of its inner face, becomes greatly attenuated at its distal third, where it is, in consequence of the obliquity of its direction, applied to the anterior face of the former bone. It then spreads into a plate extending to the inner margin of the tibia, while the solid shank is continued along the outer margin, and both terminate in the massive condyle, which embraces the whole extremity of the tibia, like an epiphysis.

"One other example only of this structure is known in the Vertebrata, of which I only find mention in Cuvier, 'Ossemens Fossiles,'

x. p. 204, tab. 249. figs. 34, 5. This author studied the distal extremity of a tibia, with applied fibular condyle, from Honfleur, which he was not able to assign to any known species or genus, but which he, with his usual sagacity, included in the chapter devoted to *Megalosaurus*. He however regarded the face of the tibia receiving the condyle-bearing bone as the inner instead of the anterior, stating that the tibia is laterally instead of antero-posteriorly compressed; so anomalous is this structure among Vertebrates. He regarded the bone as the astragalus, and did not perceive any connexion between its ascending apophysis and a fibula, partly because a fibula with distinct distal articulations was received with the same bones.

"The fibular condyle possesses an articular facet on its exterior extremity (anterior, Cuvier), probably adapted to a corresponding face of a calcaneum. Its plane is transverse, and does not cover the whole extremity, the anterior margin and a knob on the antero-superior part of the extremity projecting beyond it. Exterior to the middle of the upper margin of this piece, and at the internal base of the ascending apophysis, it is perforate, as is the cavity above the condyles of the humerus in the higher apes, and may have received a similar coronoid process of an astragalus.

"As compared with the species examined by Cuvier, this fibular condyle has a less elevated form; in Cuvier's specimen the ascending apophysis was flatter, broader, and directed towards the calcaneal facet instead of from it; it lacked the submedian perforation. Its tibial face appears to have been rounded, not angulate. The tibia presented an ascending ridge to the face by which the ascending apophysis was applied; in the *Lælaps aquilunguis* there is no ridge, the apophysis reposing in a slight concavity. This apophysis, like the slender portion of the fibula, is composed of dense bone . . . .

"The direction of the condyle indicates the articulation of the tarsal elements to have been at a considerable angle with the shank of the leg, and that the animal was entirely plantigrade and was unable to extend the foot in line with the lower leg. The animal's weight was, no doubt, shared by another tarsal bone, besides the astragalus, owing to the anterior position of the former.

"In most known *Dinosauria* the relations of the tibia and fibula are similar to those in the modern *Lacertilia*. It would appear, then, that the class existed under two ordinal modifications: the first, including *Scelidosaurus* (Ow.), *Hylæosaurus* (Mant.), *Iguanodon* (Mant.), and *Hadrosaurus* (Leidy), may be called the ORTHOPODA; the second, including *Lælaps* (Cope), and probably *Megalosaurus* (Buckl.), may be termed the GONIOPODA."*

Prof. Cope's description leaves no doubt that *Lælaps* had the tibia and the anomalous bone which articulates with it, distally fashioned in the same way as in *Megalosaurus*, the Honfleur reptile, and *Poikilopleuron*; but it will become clear by and by that the

* Proceedings of the Academy of Natural Sciences of Philadelphia, Nov. 13, 1866.

anomalous bone is certainly the astragalus, as Cuvier determined it to be, and not a part of the fibula; it will also appear, I think, that Cuvier was right, from a morphological point of view, when he dedeclared the tibia to be laterally compressed, and that there is no proof, but rather a presumption the other way, as to the plantigrade character of *Lælaps*. Finally, I shall bring forward evidence to show that the structure of the tibia and astragalus in question obtained in all the genera mentioned, so that the groups of *Orthopoda* and *Goniopoda* must be disestablished.

Prof. Cope * gave an account of the extinct reptiles which approached the birds. "He said that their approximation appeared to be at two points, the first by the *Pterosauria*, to which the modified bird *Archæopteryx* presented points of affinity. The second, and one not less striking, is by the *Dinosauria* of the orders *Goniopoda* and *Symphopoda*. He showed the essential differences between the ordinary *Dinosauria* and the birds to consist in the distinct tarsal bones in two series, the anteriorly directed pubes, and the presence of teeth, of the first class. In the genus *Lælaps* (Cope), type of the *Goniopoda*, the proximal series of the tarsal bones was principally represented by one large astragaloid piece, which had a very extensive motion on those of the second series. This was immovably bound to and embraced the tibia, and was perhaps continuous with the fibula, much resembling the structure of the foot of the chick of the ninth day, as given by Gegenbaur. The zygomatic arch was of a very light description. He was convinced that the most bird-like of the tracks of the Connecticut sandstone were made by a nearly allied genus, the *Bathygnathus* (Leidy). These creatures, no doubt, assumed a more or less erect position, and the weight of the viscera &c. was supported by the slender and dense pubic bones, which were to some extent analogous to the marsupial bones of implacental Mammalia, though probably not homologous with them.

"He said he was satisfied that the so-called clavicles of *Iguanodon* and other *Dinosauria* were pubes, having a position similar to those of the *Crocodilia*—also that a species of *Lælaps* had been observed in France, by Cuvier, which was different from the *L. aquilunguis*, and which he proposed should be called *Lælaps gallicus*.

"*Compsognathus* (Wagner), type of the *Symphopoda*, expressed the characters of the latter in the entire union of the tibia and fibula with the first series of tarsal bones—a feature formerly supposed to belong to the class Aves alone, until pointed out by Gegenbaur. This genus also offered an approach to birds in the transverse direction of the pubes (unless this be due to distortion in the specimen figured by Wagner), their position being intermediate between the position in most reptiles and in birds. Other bird-like

* Proceedings of the Academy of Natural Sciences, Philadelphia, Dec. 31st, 1867. I may remark that my memoir "On the Classification of Birds" was published in the summer of 1867 in the 'Proceedings of the Zoological Society.' Prof. Cope has evidently done me the honour to study it carefully.

features were the great number and elongation of the vertebræ of the neck, and the very light construction of the arches and other bones of the head.

"He thought the Penguin, with its separated metatarsals, formed an approach on the side of the birds; but whether the closest approximation to the *Symphypoda* should be looked for here or among the long-tailed Ratitæ (Ostrich, &c,) he was unable to indicate."

The 'Proceedings of the Boston Natural History Society' for June 18th, 1869, state that Prof. Cope "gave an account of the discovery by Dr. Samuel Lockwood, of Keyport, of a fragment of a large Dinosaur, in the clay which immediately underlies the clay-marls below the Lower Greensand bed in Monmouth County, New Jersey. The fossil represented the extremities of the tibia and fibula, with astragalo-calcaneum ankylosed to the former, in length about sixteen inches, distal width fourteen. The confluence of the first series of tarsal bones with each other and with the tibia he regarded as a most interesting peculiarity, and one only met with elsewhere in the reptile *Compsognathus* and in birds. He therefore referred the animal to the order *Symphopoda*, near to *Compsognathus*, Wagner. The extremity of the fibula was free from, and received into a cavity of the astragalo-calcaneum, and demonstrated what the speaker had already asserted, that the fibula of *Iguanodon* and *Hadrosaurus* had been inverted by their describers. The medullary cavity was filled with open cancellous tissue. The species, which was one half larger than the type-specimen of *Hadrosaurus Foulkii*, he named *Ornithotarsus immanis*."

It is very satisfactory to me to find that so able an anatomist as Prof. Cope should have been led by the force of facts to arrive, simultaneously with myself, at conclusions so similar in their general character with my own. It will be observed, however, that we differ a good deal in details. For example, it appeared to me that it was more probable that the so-called "clavicles" of the *Dinosauria* were ischia, rather than pubes; and in my diagrammatic restoration of *Iguanodon*, they are directed backwards in a manner approaching that in which the ischia of Birds are disposed, rather than in Crocodilian fashion, forwards, as Prof. Cope supposes. Prof. Cope does not allude to the strongly ornithic characters of the ilium and of the proximal ends of the tibia and fibula. In describing the astragalus of *Lælaps*, Prof. Cope states that "one other example only of this structure is known in the Vertebrata," referring to Cuvier's Honfleur reptile; but, as I shall show immediately, the astragalus is altogether similar in the commonest Birds, and probably in the whole class Aves.

Prof. Cope states that the fibulæ of the *Dinosauria* have been turned upside down by the describers of *Iguanodon* and *Hadrosaurus*. I am quite aware that the fibulæ of the former reptile have been figured the right way up by the artist and carefully inverted in the text by the describer; but if Prof. Cope will refer to my lecture, published in the 'Popular Science Review,' he will see that

what I say about the fibula is consistent only with a knowledge of the proper relations of its ends.

The further evidence as to the ornithic affinities of the *Dinosauria* which I have to bring forward in the present paper consists, first, in the structure of the pelvis, as shown by *Megalosaurus*, *Iguanodon*, and *Hypsilophodon*, and, secondly, in that of the distal end of the tibia and of the astragalus, as evidenced by *Poikilopleuron*, *Megalosaurus*, and *Lælaps*.

If the pelvis of any existing reptile be compared with that of any existing bird, the following points of difference will be observed:—

1. In the Reptile the ilium is not prolonged in front of the acetabulum; and the acetabulum is either wholly closed by bone, or presents only a moderate-sized fontanelle, as in the *Crocodilia*.

In the Bird the ilium is greatly prolonged in front of the acetabulum, and the roof of the acetabular cavity is a wide arch, the inner wall of that cavity remaining membranous. The anterior pier of the arch or præacetabular process extends further downwards than the posterior pier or postacetabular process.

Now, in all the *Dinosauria* which I have yet examined, the ilium extends far in front of the acetabulum, and furnishes only a widely arched roof to that cavity, as in Birds. It retains a reptilian character in the further proportional extension of the postacetabular process downwards.

2. The ischium in the Reptile is a moderately elongated bone, which becomes connected with the pubis in the acetabulum, and extends downwards, inwards, and somewhat backwards, to unite with its fellow in a median ventral symphysis. The obturator space is not interrupted by any forward process of the outer and anterior half of the ischium.

In all birds the ischium is elongated and inclined backwards, the backward direction being least marked in *Apteryx*, and most in *Rhea*. The ischia never come together directly in a median ventral symphysis, though they unite dorsally in *Rhea*. The anterior edge of the external half of the ischium very generally sends off a process which unites with the pubis, thus dividing the obturator space.

In all the *Dinosauria* in which I have been able to identify the bone (*Thecodontosaurus*, *Teratosaurus*, *Megalosaurus*, *Iguanodon*, *Stenopelyx*, *Hadrosaurus*, *Hypsilophodon*), the ischium is greatly elongated. In *Iguanodon* it has the *obturator* process characteristic of the same bone in Birds; and I imagine that the same process is seen in *Compsognathus*. In *Hypsilophodon* there can be no mistake about the matter, and the remarkable slenderness and prolongation of the ischium gives it a wonderfully ornithic character. In *Iguanodon* this slenderness and prolongation are carried beyond what is to be seen in Birds. I am disposed to think, however, that, as was certainly the case in *Hypsilŏphodon*, the ischia united in a median ventral symphysis in all the *Dinosauria*.

Fig. 3.

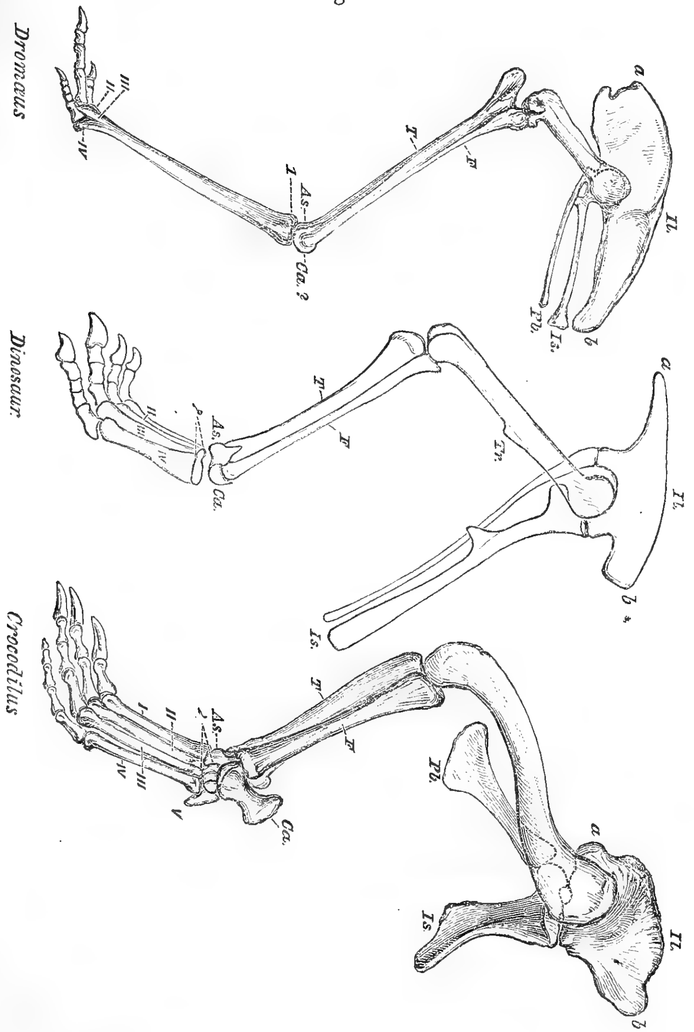


Fig. 3. The pelvis and hind limb of an Emu (*Dromæus*) and a Crocodile (*Crocodilus*), for comparison with the diagrammatic restoration of the corresponding parts in an Iguanodontoid Dinosaurian. The bones of the Bird are in their natural position; in the Dinosaur it may be a question whether the metatarsus was so much raised; in the Crocodile the foot would, naturally, be flat upon the ground, and the thigh turned out nearly at right angles to the body. The letters have the same signification throughout; *Il*, ilium; *a*, *b*, its anterior and posterior extremities; *Is*, ischium, *Pb*, pubis; *Tr*, trochanter of the femur of the Dinosaur; *T*, tibia; *F*, fibula; *As*, astragalus; *Ca*, calcaneum; 1, the distal division of the tarsus; I, II, III, IV, V, the digits.

Thus the ischia of a Dinosaurian are more bird-like than those of any existing reptile, but retain the reptilian union in a symphysis.

3. In all reptiles the pubis is inclined forwards as well as downwards towards the ventral median line. In all except the Crocodile it takes a considerable share in the formation of the acetabulum; and in all, except the Crocodile again, the ossified pubis unites directly with its fellow in the middle line. In the Crocodiles, the inner extremities of the pubes remain cartilaginous for a great extent, and consequently the ossified parts of the pubes remain widely apart in the dry skeleton.

Prof. Phillips has shown me what I believe to be fragments of the pubes of *Megalosaurus* in the Oxford Museum. If the determination is correct, they resembled those of the Ostrich in many respects. As they are detached, there is no certainty respecting their direction. The pubes of *Compsognathus* are, unfortunately, obscured by the femora. They seem to have been very slender; and they are directed forwards and downwards, like those of lizards. Some lizards, in fact, have pubes which, if the animal were fossilized in the same position as *Compsognathus*, would be very similar in form and direction.

Hypsilophodon, however, affords unequivocal evidences of a further step towards the bird. The pubes are not only as slender and elongated as in the most typical bird, but they are directed downwards and backwards parallel with the ischia, thus leaving only a very narrow and elongated obturator foramen, which is divided by the obturator process. I suspect that if only the pubis and the ischium of *Hypsilophodon* had been discovered, they would have been unhesitatingly referred to *Aves*.

Thus, as far as its pubis is concerned, *Hypsilophodon* affords an unmistakable transition between *Reptilia* and *Aves*. It remains to be seen how far the hypsilophodont modification extended among the *Dinosauria*. The remains of *Compsognathus* and of *Stenopelyx* lead me to suppose that it was by no means universal. In fact in this, as in many other respects, I have reason to think that the *Dinosauria* present us with serial modifications leading from the Parasuchian* type of structure, on the one hand, to that of Birds on the other.

The evidence yielded by the distal end of the tibia and the astragalus has the same tendency.

In the splendid collection of Megalosaurian remains in the possession of Mr. James Parker, of Oxford, which I had the good fortune to see a few weeks ago, I recognized the astragalus of that reptile, which, as I had already divined from the structure of the tibia, is altogether like the corresponding bone in *Poikilopleuron*.

In another specimen the distal end of the tibia and the fibula were in place, and there was the impression of the ascending process of the astragalus, with a fragment of its bony substance, exactly where it should be. With this complete knowledge of the

* By the generic name *Parasuchus* I indicate a reptile from the Indian Trias, which I hope shortly to describe, and which is clearly allied to *Belodon*.

tibia, fibula, and astragalus of such a typical Dinosaurian as *Megalosaurus*, let us compare these bones with the corresponding bones of Reptiles and Birds, as we have compared the pelvis.

In Reptiles (ordinary *Lacertilia* and *Crocodilia*, namely, which are alone at present under consideration),—

1. The proximal end of the tibia has but a very small or quite rudimentary cnemial crest, and it presents no ridge for the fibula on its outer side.

2. The flattened sides of the distal end of the tibia look, the one directly forwards, or forwards and inwards; and the other backwards, or backwards and outwards. And when the posterior edges of the two condyles of the proximal ends of the tibia rest on a flat surface which looks forwards, the long axis of the distal end is either nearly parallel with that surface, or is inclined obliquely from in front and without backwards and inwards.

3. There is no depression in the anterior face of the tibia for the reception of an ascending process of the astragalus.

4. The distal end of the fibula is as large as, or larger than, the proximal end, and articulates largely with a facet on the outer part of the astragalus.

5. The astragalus is not depressed and flattened from above downwards, nor does it send a process upwards in front of the tibia.

6. The astragalus remains quite free from the tibia.

In all these respects any ordinary bird, say a fowl, is very strikingly contrasted with the reptile.

1. The proximal end of the tibia is produced forwards and outwards into an enormous cnemial crest; and, on the outer side, there is a strong ridge for the fibula.

2. When the posterior edges of the condyles of the tibia rest upon a flat surface, the one flat surface of the distal end of the bone looks outwards as well as forwards, and the other inwards as well as backwards, and the axis of the distal end is inclined at an angle of 45° to the flat surface from within and in front, backwards and outwards, thus exactly reversing the direction in the Reptile.

3. There is a deep longitudinal depression on the anterior face of the distal end of the tibia, which receives an ascending process of the astragalus.

4. The distal end of the fibula is a mere style, and does not directly articulate with the astragalus.

5. The astragalus is a much-depressed bone, with a concave proximal and a convex, pulley-like distal surface. A process ascends from its front margin in the groove in the front face of the tibia. This process is comparatively short, and perforated by two canals for the *tibialis anticus* and *extensor communis* in the Fowl, while in the Ostrich and Emu it is extremely long and not so perforated.

6. The astragalus becomes ankylosed with the tibia (though it remains distinct for a long time in the Ostrich and *Rhea*, and in some breeds of fowls).

Now in every one of these particulars, except perhaps the last, *Megalosaurus* is far more like a bird than it is like a reptile.

1. There is a great cnemial crest and a ridge for the fibula.

2. The disposition of the distal end of the tibia is literally that observed in the bird.

Fig. 4.

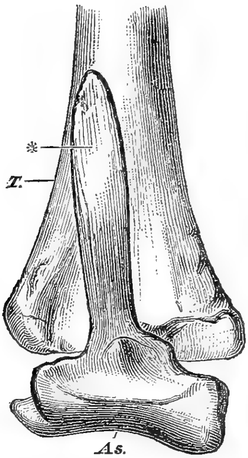


Fig. 4, front view.

Fig. 5.

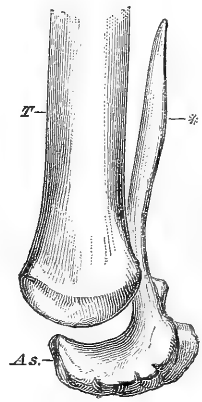


Fig. 5, side view.

The distal end of the tibia (*T*), with the astragalus (*As*), of a young Ostrich in the Museum of the Royal College of Surgeons. * the ascending process of the astragalus.

3. There is a fossa for the reception of the ascending process of the astragalus.

4. The distal end of the fibula is much smaller than the proximal, though not so slender as in *Aves*. It cannot articulate with the astragalus in the precise way observed in Reptiles.

5. The astragalus is altogether similar to that of a bird, with a short ascending process. I suspect that the perforation observed in this process in *Lælaps* by Prof. Cope, is the opening of a canal or canals for tendons, as in the fowl.

6. The astragalus appears to have remained distinct from the tibia throughout life in *Megalosaurus*; but it seems to have become ankylosed in *Compsognathus*, and Prof. Cope describes it as ankylosed in *Ornithotarsus*. I believe I have evidence of the same coalescence in *Euskelosaurus*.

I find that the tibia and the astragalus of a Dorking fowl remain readily separable at the time at which these birds are usually brought to table. The cnemial epiphysis is also easily detached at this time. If the tibia without that epiphysis and the astragalus were found in the fossil state, I know not by what test they could be distinguished from the bones of a Dinosaurian. And if the whole hind quarters,

from the ilium to the toes, of a half-hatched chicken could be suddenly enlarged, ossified, and fossilized as they are, they would furnish us with the last step of the transition between Birds and Reptiles; for there would be nothing in their characters to prevent us from referring them to the *Dinosauria*.

Discussion.

Sir Roderick Murchison, who had taken the Chair, inquired as to the habits of the *Hypsilophodon*.

Mr. Hulke mentioned that Mr. Fox had two blocks containing remains of a large portion of the *Hypsilophodon*, all procured from a thin band of sandstone near Cowleaze Chine. On one the pelvis is almost entire, as well as the right femur, the tibia (which is longer than the femur), four long metatarsal bones, and an astragalus. All the long bones are hollow. Portions of at least eight individuals have been found in the same bed.

Mr. Seeley doubted whether these animals should be called Reptiles at all, as they seemed to him to form a group distinct alike from reptiles, birds, and mammals, but occupying an intermediate position. In the hinder limbs of *Pterodactylus* the analogies were closer with mammals than with birds. He thought it possible that the peculiar structure of the hinder limbs of the Dinosauria was due to the functions they performed rather than to any actual affinity with birds.

The President, in reply, stated that *Hypsilophodon*, from the character of its teeth, probably subsisted on hard vegetable food. He expressed a hope that Mr. Fox would allow a closer examination of his specimens to be made. He was unable to agree with Mr. Seeley's views. He was inclined to think that the progress of knowledge tended rather to break down the lines of demarcation between groups supposed to be distinct than to authorize the creation of fresh divisions.

November 24, 1869.

Robert Arnold Barker, M.D., Civil Medical Officer, Cachar, Bengal, was elected a Fellow of the Society.

The following communications were read:—

1. *On the Classification of the* Dinosauria, *with observations on the* Dinosauria *of the* Trias. By T. H. Huxley, LL.D., F.R.S., President of the Geological Society.

[Plate III.]

I. The Classification and Affinities of the Dinosauria.

Contents.

1. *The History and Definition of the Group.*

The recognition of what are now commonly termed the *Dinosauria*, as a peculiar group of the *Reptilia,* is due to that remarkable man whose recent death all who are interested in the progress of sound palæontology must deplore—Hermann von Meyer. In his 'Palæologica,' published so long ago as 1832*, Von Meyer classifies fossil reptiles according to the nature of their locomotive organs; and his second division, defined as "Saurians, with limbs like those of the heavy terrestrial Mammalia," is established for *Megalosaurus* and *Iguanodon.* To this group Von Meyer subsequently applied the name of *Pachypodes* or *Pachypoda.*

Nine years afterwards Professor Owen, in his "Report on British Fossil Reptilia," conferred a new name upon the group, and attempted to give it a closer definition, in the following passages :—

" *Dinosaurians.*—This group, which includes at least three well-established genera of Saurians, is characterized by a large sacrum composed of five ankylosed vertebræ of unusual construction, by the height and breadth and outward sculpturing of the neural arches of the dorsal vertebræ, by the twofold articulation of the ribs to the vertebræ, viz. at the anterior part of the spine by a head and tubercle, and along the rest of the trunk by a tubercle attached to the transverse process only; by broad and sometimes complicated coracoids and long and slender clavicles, whereby Crocodilian characters of the vertebral column are combined with a Lacertian type of the pectoral arch; the dental organs also exhibit the same transitional or annectent characters in a greater or less degree. The bones of the extremities are of a large proportional size for Saurians; they are provided with large medullary cavities and with well-developed and unusual processes, and are terminated by metacarpal, metatarsal, and phalangeal bones which, with the exception of the ungual phalanges, more or less resemble those of the heavy pachydermal mammals, and attest, with the hollow long bones, the terrestrial habits of the species.

" The combination of such characters, some, as the sacral ones, altogether peculiar among reptiles, others borrowed, as it were, from groups now distinct from each other, and also manifested by crea-

* Von Meyer refers to the 'Isis' for 1830, as containing the first sketch of his views. I have not verified the citation.

tures far surpassing in size the largest of existing reptiles, will, it is presumed, be deemed sufficient ground for establishing a distinct tribe, or suborder, of Saurian reptiles, for which I would propose the name of *Dinosauria*.

"Of this tribe the principal and best-established genera are the *Megalosaurus*, the *Hylæosaurus*, and the *Iguanodon*, the gigantic crocodile lizards of the dry land, the peculiarities of the osteological structure of which distinguish them as clearly from the modern terrestrial and amphibious *Sauria* as the opposite modifications for an aquatic life characterize the extinct *Enaliosauria*, or marine lizards"*.

Further on it is stated that "the Reptilian type of structure made the nearest approach to mammals" in the *Dinosauria* (*l. c.* p. 202).

Every character which is here added to Von Meyer's diagnosis and description of his *Pachypoda* has failed to stand the test of critical investigation; while it is to birds and not to mammals that the *Dinosauria* approach so closely. There is, in fact, not a single specially mammalian feature in their whole organization.

Even in point of etymological appropriateness, the term "*Dinosauria*" is no more fitting for reptiles of which some are small, than "*Pachypoda*" is for reptiles of which some have slender feet; but as Von Meyer's name has never obtained much currency, it may be well to allow justice to give way to expediency, and to retain the name of *Dinosauria* for those reptiles which agree in all the most important and characteristic parts of their structure with *Megalosaurus* and *Iguanodon*.

The group thus limited is susceptible of very clear diagnosis from all other reptiles, inasmuch as its members present the following combination of characters:—

1. The dorsal vertebræ have amphicœlous or opisthocœlous centra. They are provided with capitular and tubercular transverse processes, the latter being much the longer.

2. The number of the vertebræ which enter into the sacrum does not fall below two, and may be as many as six.

3. The chevron bones are attached intervertebrally, and their rami are united at their vertebral ends by a bar of bone.

4. The anterior vertebral ribs have distinct capitula and tubercula.

5. The skull is modelled upon the Lacertilian, not on the Crocodilian type. There is a bony sclerotic ring.

6. The teeth are not ankylosed to the jaws, and may be lodged in distinct sockets. They appear to be present only in the præmaxillæ, maxillæ, and dentary portions of the mandible.

7. The scapula is vertically elongated; the coracoid is short, and has a rounded and undivided margin. There is no clavicle.

8. The crest of the ilium is prolonged both in front of and behind the acetabulum; and the part which roofs over the latter cavity forms a wide arch, the inner wall of the acetabulum having been formed by membrane, as in birds.

9. The ischium and pubis are much elongated.

10. The femur has a strong inner trochanter; and there is a crest

* Prof. Owen's "Report on British Fossil Reptiles," 1841.

on the ventral face of the outer condyle, which passes between the tibia and the fibula, as in birds.

11. The tibia is shorter than the femur. Its proximal end is produced anteriorly into a strong crest, which is bent outwardly, or towards the fibular side.

12. The astragalus is like that of a bird; and the digits of the pes are terminated by strong and curved ungual phalanges.

The *Dinosauria* about which we have sufficient information appear to me to fall into three natural groups—i. the *Megalosauridæ*, ii. the *Scelidosauridæ*, and iii. the *Iguanodontidæ*.

i. The *Megalosauridæ*.

1. The maxillary teeth are sharp-pointed, and the crown has a longitudinal serrated ridge, either on the middle of its posterior face only, or on the middle of its anterior face as well. The serrations of the ridge are directed at right angles to the long axis of the tooth. The teeth do not become worn by mastication.

2. The anterior prolongation of the ilium is nearly as large as, or larger than, the posterior.

3. The rami of the mandible are deep and thick and meet by rounded ends in the symphysis.

4. The proximal end of the femur is flattened, curved, and twisted in such a manner that its plane is oblique to that of a flat surface on which the condyles rest. In other words, it is more or less crocodilian.

5. There is no dermal armour.

Teratosaurus, *Palæosaurus*, *Megalosaurus*, *Poikilopleuron*, *Lælaps*, and probably *Euskelosaurus* belong to this group.

ii. The *Scelidosauridæ*.

1. The maxillary and mandibular teeth have sharp-edged triangular crowns, with serrated margins, the serrations being oblique to, or parallel with, the long axis of the tooth. The teeth are not worn down by mastication.

2. The anterior prolongation of the ilium is more slender than the posterior.

3. The rami of the mandible are slender, and taper to their symphysis.

4. The proximal end of the femur has a subglobular articular head, borne by a neck which is set nearly at right angles to the axis of the shaft, while its direction is nearly parallel with a flat surface on which the condyles rest.

5. The integument is (usually) provided with a dermal armour in the form of bony scales or spines.

Thecodontosaurus, *Hylæosaurus*, *Polacanthus* (?), and *Acanthopholis* belong to this division.

iii. The *Iguanodontidæ*.

1. The maxillary and mandibular teeth have obtuse subtriangular crowns; the surface of the enamel being ridged on one or both sides. The crowns of the teeth are worn down flat by mastication.

2. The anterior prolongation of the ilium is more slender than the posterior.

3. The rami of the mandible unite in an excavated edentulous symphysis, which receives an edentulous prolongation of the præmaxillæ.

4. The proximal end of the femur is as in the *Scelidosauridæ*.

5. There is no dermal armour.

*Cetiosaurus**, *Iguanodon*, *Hypsilophodon*, *Hadrosaurus*, and probably *Stenopelyx*† belong to this division.

These three groups appear to me to be very well marked; but I do not propose them with the intention of suggesting that there are no others, or that the progress of discovery will leave them thus well defined.

The very remarkable reptile, *Compsognathus longipes*, has many affinities with the *Megalosauridæ*, *Scelidosauridæ*, and *Iguanodontidæ*, but it presents, at the same time, so many differences from all these, and so much of its structure is left unrevealed by the solitary specimen which exists, that perhaps the most convenient course which can be adopted, at present, is to make it the representative of a group equivalent to them. *Compsognathus* differs from all the preceding forms in the length of the cervical relatively to the thoracic vertebræ, and in the femur being considerably shorter than the tibia‡.

2. *Establishment of the Order* ORNITHOSCELIDA *to include the* Dinosauria *and the* Compsognatha.

But *Compsognathus* agrees with the *Megalosauridæ*, *Scelidosauridæ*, and *Iguanodontidæ* in the ornithic modification of the Saurian type, which is especially expressed in the hind limbs; and I therefore propose to unite it with them in one group, which I shall term ORNITHOSCELIDA. This group will contain two primary subdivisions:

* I assign this place to *Cetiosaurus* on the evidence of the splendid series of remains of this reptile which Prof. Phillips showed me in the Oxford Museum.

† Von Meyer has described a reptile from the German Wealden, in the 'Palæontographica' for 1859, under the name of *Stenopelyx Valdensis*. Only the pelvis, a few vertebræ, and the left hind limb of this very interesting genus are preserved; but they suffice to prove it to be a Dinosaurian. There are four digits in the foot, the fifth being absent, while the hallux is smaller than the others. The fibula is slender; the tibia stout and apparently as long as the femur, the head of which is at right angles with the shaft. The ischia are in place and longer than the femur; they are stouter in proportion than in *Iguanodon* or *Hypsilophodon*, and quite differently formed. What Von Meyer regards as the pubes are, if I mistake not, the anterior prolongations of the ilia.

From the absence of any dermal armour, one would be disposed to arrange *Stenopelyx* among the *Iguanodontidæ*; but many of its characters are very peculiar.

‡ Professor Cope has distinguished *Compsognathus* as the type of a division, *Ornithopoda*, from the rest of the Dinosauria, which he terms *Goniopoda*. The *Ornithopoda* have the astragalus ankylosed, while in the *Goniopoda* it is free. But there is much reason to believe that the astragalus became ankylosed in some of the "Goniopoda;" and it seems to me precisely by the structure of the foot that *Compsognathus* is united with, instead of being separated from, the *Ornithoscelida*.

—I. The *Dinosauria*, with the cervical vertebræ relatively short, and the femur as long as, or longer than the tibia. II. The *Compsognatha*, with the cervical vertebræ relatively long, and the femur shorter than the tibia.

3. *The affinities of the* ORNITHOSCELIDA *with other Reptiles.*

If we consider the relations of the *Ornithosauria* to other reptiles, it is at once obvious that they belong to that great division of the class in which the thoracic vertebræ have distinct capitular and tubercular processes, the latter being longer than the former, and springing from the arch of the vertebræ, as in the crocodiles. These reptiles may be termed *Suchospondylia*, to distinguish them from another great group, in which the thoracic vertebræ have the capitular and tubercular processes fused together into one process or facet, and which may be termed the *Erpetospondylia*,—from a third, in which the capitular and tubercular processes are both mere tubercles springing from the centrum of the thoracic vertebræ, *Perospondylia*,—and from a fourth, *Pleurospondylia*, in which the thoracic vertebræ have neither capitular nor tubercular transverse processes, but the ribs are sessile upon, and fixed to, the vertebræ.

The last-named group consists of the *Chelonia*; the *Perospondylia* contain only the *Ichthyosauria*; the *Erpetospondylia* comprise the *Ophidia*, *Lacertilia*, and *Plesiosauria*; while the *Suchospondylia* embrace the *Crocodilia*, the *Dicynodontia*, the *Pterosauria*, and the *Ornithoscelida*.

The closest relations of the *Ornithoscelida* within this group are with the *Dicynodontia* on the one hand, and the *Crocodilia* on the other. The sacrum and the iliac bones of the Dicynodonts more closely resemble the corresponding parts of the *Ornithoscelida* than they do those of any other *Reptilia*, except the *Pterosauria**; and there are a good many points of resemblance in the skull and dentition. Our knowledge of *Rhopalodon* and of *Galesaurus* is hardly sufficient to afford grounds for a safe opinion; but it seems probable that they will turn out to be annectent forms between the *Dicynodontia* and the *Ornithoscelida*.

The connexion of the *Crocodilia* with the *Ornithoscelida* is probably to be sought in some common form, more Lacertilian in its character than any of the known members of either of these groups. The oldest known Crocodilians, *Belodon* and its congeners, exhibit modifications which approximate them rather to the *Lacertilia* than to the *Ornithoscelida*.

If we seek for reptilian allies of the *Ornithoscelida* in formations of older date than the Trias, the Permian forms alone present themselves. Our knowledge of these is almost entirely due to the researches of Von Meyer, the results of whose investigations have hardly received the attention they deserve. They prove the existence of two very distinct reptilian genera, *Proterosaurus*† and *Para-*

* The complete occlusion of the obturator foramen by bone occurs in both the *Dicynodontia* and the *Pterosauria*, and in these alone among Reptiles.

† The generic distinctness of *Aphelosaurus* of Gervais appears to me to be doubtful.

saurus, in the Kupferschiefer, and two others, *Phanerosaurus* and *Sphenosaurus*, different from them and from one another, in the Rothliegende, in which formation also a peculiar Labyrinthodont, *Osteophorus*, occurs.

Proterosaurus appears to me to be a true Lacertilian. At least, neither in Von Meyer's figures and descriptions, nor in the one classical specimen which exists in this country can I find evidence of any essential departure from the old Lacertilian plan of structure, such as is exhibited by *Hyperodapedon* or *Telerpeton*—though it must be confessed that the long neck, light head, and short fore-limbs, to say nothing of the opisthotonic death-spasm which has left the fossils in their present position, remind one curiously of *Compsognathus*.

Parasaurus has four ankylosed sacral vertebræ, with great sacral ribs; and perhaps the two vertebræ which succeed these must be counted as sacral. It would appear from the figures, that the anterior ribs may have been, and probably were, divided into a distinct capitulum and a tuberculum. From the position of the undisturbed femora in one specimen, it cannot be doubted that the ilia must have extended a long way in front of the acetabulum. The length of the short and stout femur does not exceed that of four conjoined vertebræ; and there is some reason to think that the bones of the leg were considerably longer than the femur.

Parasaurus therefore belongs to a totally different group of reptiles from *Proterosaurus*, and I can compare it with nothing but the *Ornithoscelida* and the *Dicynodontia*.

The structure of both *Proterosaurus* and *Parasaurus* leads to the belief that they were terrestrial reptiles; and their occurrence in the Kupferschiefer is no bar to this conclusion, as land-plants abound in that rock.

The *Phanerosaurus* of the Rothliegende is based upon a series of half-a-dozen vertebræ, the characters of which are altogether peculiar.

Sphenosaurus, on the other hand, seems to me to be a Lacertilian, though of a very different character from *Proterosaurus*.

On the whole, I am disposed to think that *Parasaurus* is related on the one hand to the *Ornithoscelida* and the *Dicynodontia*, and on the other to some much older and less specialized reptilian form. I can by no means bring myself to believe that the Reptilia commenced their existence in the Permian epoch with such specialized characters as are observable in the four known genera of that age.

4. *The affinities of the* Ornithoscelida *with Birds.*

I have treated of the relations of the *Ornithoscelida* with birds at length in a former paper, and I will merely repeat here that I know of no circumstance by which the structure of birds, as a class, differs from that of reptiles, which is not foreshadowed in the *Ornithoscelida*. Nor am I acquainted with any reptiles which can be compared in the strength and minuteness of their ornithic affinities with the *Ornithoscelida*.

It may be said that the form and mode of connexion of the sca-

pula and the coracoid, and the crested and broad sternum, of the *Pterosauria* are marks of affinity with birds, as strong as those which the hind limb and pelvis present in the *Ornithoscelida*. But I think this argumentation is invalid; for the shoulder-girdle of an ostrich or of an apteryx is more similar to that of an Ornithoscelidan than it is to that of a Pterodactyle, these special peculiarities of the shoulder-girdle, like the crest of the sternum, having relation to physiological action, and not to affinity. If the strongly crested sternum and the acute angulation of the union of the scapula and coracoid were marks of ornithic affinity, they would be found in all birds. The contrary is true: they are found only in those birds which fly; and the crest exists in bats, which cannot be said to have any affinity with birds.

On the other hand, the peculiarities of the hind limb and pelvis which the *Ornithoscelida* share with birds are found in all birds. It may be said that all birds stand upon their hinder feet, and that, as the *Ornithoscelida* did the same, the resemblance of structure arises from a resemblance of function. But I doubt if the majority of the *Dinosauria* stood more habitually upon their hind limbs than Kangaroos or Jerboas do; and unless there was some genetic connexion between the two, I see no reason why the hind limbs of *Ornithoscelida* should resemble those of birds more than they resemble those of kangaroos.

Finally, with regard to the sternum, although there is no likelihood that the *Ornithoscelida* possessed a crested sternum, yet there is some evidence that they were provided with a very broad and expanded breast-bone, more like that of a bird than it is like that of any reptile. I shall discuss this evidence below, in speaking of the Dinosaurian remains discovered by Plieninger in the Trias near Stuttgart.

II. The Dinosauria of the Trias.

Contents.

1. Dinosauria *from the Trias of Germany and Central Europe.*

The first recognition of the occurrence in the Trias of Dinosaurian remains as such, with which I am acquainted, is contained in the following extract from a letter, addressed by H. von Meyer to Bronn, and published in the 'Jahrbuch' for 1857.

"Dr. Engelhardt, of Nuremberg, brought to the meeting of Naturalists in Stuttgart some bones of a gigantic animal from a brecciated sandstone of the Upper Keuper of his neighbourhood. He had the kindness to submit to me all the bones which had been obtained. I have already examined them, and have drawn the best, which consisted of almost entire limb-bones and of vertebræ.

"The discovery is extremely interesting. The bones belong to a

gigantic Saurian, which, in virtue of the mass and hollowness of its limb-bones, is allied to *Iguanodon* and to *Megalosaurus*, and will belong to the second division of my Saurian system. None of its allies has hitherto been found so deep in the European continent, nor from rocks of so great age. These remains belong to a new genus, which I term *Plateosaurus*; the species is *Pl. Engelhardtii*. I shall hereafter publish a full account of the fossils."

The fuller account which Von Meyer promises is contained in that splendid monument of palæontological genius and industry, the 'Saurier des Muschelkalkes,' which came out between 1847 and 1855. The remains enumerated consist of a few imperfect fragments of a cranium without jaws or teeth, six more or less fragmentary separate vertebræ, an imperfect sacrum (consisting of, at fewest, three ankylosed vertebræ), fragments of ribs, and several limb-bones. The centra of the vertebræ are nearly four inches long, and the most perfect limb-bone is about sixteen inches long.

This bone is represented in tab. 69. figs. 1–3 of the work cited. Von Meyer appears to be inclined to consider it a tibia, comparing the smaller end of the bone to the distal end of the tibia of *Poikilopleuron*; and the figures support the determination. The other figures on the same plate (4, 5) represent the distal end of a femur, the posterior face of the outer condyle of which exhibits the remains of the ridge which plays between the tibia and the fibula, and is so characteristic of the *Dinosauria* among reptiles.

In the summary of results at the end of the 'Saurier des Muschelkalkes,' the following paragraph occurs (p. 162):—

"As to the family of the *Pachypoda*, with their colossal massive forms, it is certain that it is to be met with in the Upper Keuper, where it is represented by the two genera *Belodon* and *Plateosaurus*, each having one species, *B. Plieningeri* and *P. Engelhardtii*. These are different from the *Pachypoda* of the Oolite and the Chalk."

And further on, at p. 163:—

"Concerning the other Saurians, with flat, cutting teeth, which are comprehended under *Cladyodon*, *Thecodontosaurus*, *Palæosaurus*, and *Zanclodon*; it has not yet been made out to what family they belong, nor whether they are allied to the *Pachypoda* or not. They appear in rocks which occupy the horizon of the lower 'Grenzbreccia,' and therefore appear to represent a Muschelkalk which is passing into the 'Lettenkohl;' they occur besides in the actual Lettenkohl and in the Keuper. The North-American genera *Clepsysaurus* and *Bathygnathus* appear to be allied forms."

It will be observed that Von Meyer here reckons *Belodon* among the *Pachypoda*. The study of the more complete remains of *Belodon*, described in the 'Reptilien aus dem Stubensandstein des oberen Keupers' (Palæontographica, Bd. vii. 1861), however, led to a different conclusion, which is thus expressed (*l. c.* p. 346):—"Hence *Belodon* was no Pachypode; if Plieninger has declared it to be such, it is because he has mixed up the remains of two totally different animals. *Belodon* was plainly more of a crocodile than of a lizard."

The researches of Prof. Plieninger referred to by Von Meyer are

detailed in the memoir entitled "*Belodon Plieningeri* (H. v. Meyer), ein Saurier der Keuperformation," which was published in the seventh annual issue of the 'Jahreshefte des Vereins für vaterländische Naturkunde in Württemberg,' and was published in 1857. This valuable memoir contains a description, accompanied by numerous figures, of all that could be found of two skeletons of reptiles of great size, which were discovered near Stuttgart, in the "red Keuper marl" which forms the uppermost part of the Trias in that region. One of these skeletons was discovered by Herr Reiniger, the other by Prof. Plieninger himself. Both were in a much shattered condition, and were devoid of the skull. The remains of the first skeleton, which I shall call A, comprised, according to Prof. Plieninger, sixty, more or less complete, successive vertebræ, the pelvis, the hind legs down to the phalanges, the humeri, a great number of fragments of ribs, the sternum, and thirteen isolated crowns of teeth, some entire digits, and separate phalanges. Of these, Plieninger figures what he describes as the best-preserved teeth and digital bones—the right and left humeri, with attached fragments of the ulna and radius and of the shoulder-girdle, the left femur, the left tibia, with attached fragments of the fibula and the right tibia, and a massive bone, the nature of which is doubtful.

The remains of the second skeleton (B) include what Prof. Plieninger determines as:—the entire pelvis, the ilia being separated from the sacrum, which consists of three bones, two only of which are ankylosed; a femur; an ischium; a few bones of the feet; the two scapulæ; one perfect humerus, and the other pathologically deformed; together with the eight vertebræ which preceded the sacrum, with all their processes entire, and in their natural relations to one another and the sacrum.

All these remains were found together. At four feet distance on the same level, and continuing the direction of the vertebral column, was a second series of seven vertebræ, five and two of them being respectively associated together. No remains of any other animal, or any other individual, were found along with these two skeletons, which clearly appertain to the same species. The evidence which they afford as to the nature of the reptiles to which they belonged, is therefore of very great value. This evidence has already been discussed by Von Meyer (*l. c.* p. 268), who concludes that the skeletons are not referable to *Belodon*, and judges, from "a certain resemblance to the corresponding parts of *Megalosaurus Bucklandi*," that they might have belonged to a Pachypode, and possibly to *Teratosaurus*, a reptile from the same locality and bed, the jaw of which he describes.

In this view I entirely concur. In fact, Plieninger's figures, (which do not quite deserve the reproaches with which Von Meyer visits them) prove that the skeletons A & B belong to *Dinosauria*. But they also seem to me to show that one or two of Plieninger's determinations are erroneous. Thus, the two vertebræ of B, represented in tab. xii. fig. 14, are certainly cervical. The bone called "ischium" (tab. xii. fig. 5) is the united scapula and coracoid, having a characteristically Dinosaurian form. On the other hand, the

so-called "scapula" (tab. x. fig. 7) looks to me very much like the ischium; but the figure is not of such a character as to allow me to speak with confidence on this point. Putting the information yielded by these two skeletons together, it proves the existence in the Upper Trias of Stuttgart of a Dinosaurian of great size.

The sixty vertebræ which lie in uninterrupted series in the specimen A, occupy a length of seventeen Württemberg feet. Thirty-seven of these vertebræ form a tail eight feet long. Two (more probably three) vertebræ in the sacrum take up a foot, while the twenty-one præsacral vertebræ form a series 7 feet long. The centrum of the last caudal vertebra is 1·5 in. long, and rather less than 1 in. in vertical height of the articular surface; and the tail is not complete. The middle caudal vertebræ have centra 2·5 in. long, with a height of 1·25 in. Further towards the sacrum the centra are 4 inches high and 3 inches long. The hindermost of the præsacral vertebræ have the articular surface of the centra 6 inches wide, and are from 5 to 6 in. long. They diminish in size forwards; and the five most anterior, which together occupy 2 feet, have about the dimensions of the middle caudal vertebræ. The centra are all constricted in the middle of their length, and have slightly concave articular surfaces. The articular faces of the centra are almost circular in contour. The spinous process is flat, quadrangular, 3·4 in. high, 4·5 in. long. It follows from this account that the two cervical vertebræ of the specimen B, which are opisthocœlous, must have had their place in front of the twenty-one præsacral vertebræ shown to exist by A; and as neither of these is axis or atlas, there must have been, at fewest, twenty-five præsacral vertebræ, which is one more than exists in a crocodile. But as the tubercular transverse processes of the cervical vertebræ in question arise low down in their arches, and the capitular processes lie below the middle of the centrum, they may well be anterior cervicals. The characters of the dorsal vertebræ, as shown by the two consecutive series of five and eight respectively in B, are very singular, and in some respects anomalous.

The sacrum is unlike that of other *Dinosauria*, in possessing only two completely ankylosed vertebræ. On the other hand, the expansion and coalescence of the sacral ribs at their extremities is characteristically Dinosaurian. No chevron bones are described or figured.

One of the most remarkable portions of the skeleton A is an oblong plate of bone, nearly two feet long, and having apparently half that width, with edges which vary from one to three inches in thickness. The anterior external angles are prolonged into stout processes, which are directed upwards and inwards and are somewhat recurved. Professor Plieninger considers this bone to be the sternum; and I see no reason for dissenting from his interpretation. A *Rhea* of the same size as the triassic Dinosaurian would present a sternum of very similar proportions, especially as regards the antero-lateral or *pleurosteal* processes.

The scapula of B has a length of 21 inches. It is long and narrow. The coracoid is short and rounded, as in other *Dinosauria*. The humerus of A is rather more than 17 inches long; but that of B

must have been 20 in. long, if the drawing is correct. Probably therefore B was a larger animal, and the length of the shoulder-bones of A must be proportionally reduced. The femur of A is $27\frac{1}{2}$ in. long; the tibia about 20 in. long. The ilium of B seems to have been not less than 16 in. long.

In the Maidstone *Iguanodon*, the scapula is 29 in., the humerus is 19 ins., the femur 33 in., the tibia 31 in., the ilium 30 in. long; so that the hind limbs were much longer in proportion to the fore limbs, the tibia in proportion to the femur, and the scapula in proportion to the humerus than in the Stuttgart Dinosaurian. The hinder dorsal vertebræ have centra rather less than 4 in. long, and fully 4 in. high, whence *Iguanodon* would seem to have possessed a shorter trunk in relation to its limbs.

The associated remains of a *Megalosaurus* which Mr. James Parker, of Oxford, was good enough to show me some time ago has ilia which are 26 inches long, femora 32 inches; and the tibiæ could not have been much shorter than the femora. *Scelidosaurus* has the ilium 16 inches long, the femur 16–17 inches, the tibia 13 inches, the scapula 13 inches, the humerus 11·25 inches. The length of a dorsal vertebra is $2\frac{1}{3}$–$2\frac{1}{2}$ inches. Thus, in the proportions of the tibia to the femur and of the humerus to the femur, the Triassic reptile comes nearer to the Liassic *Scelidosaurus* than any other Dinosaurian; but the limbs are shorter in proportion to the vertebræ than they are even in *Scelidosaurus*.

The facts now detailed show that, as I have already hinted, for the last ten years ample evidence of the existence of at least two genera of *Dinosauria* in the German Trias has been in existence.

But in 1861 Von Meyer described and founded the genus *Teratosaurus* upon a left maxilla with teeth, which he declared to be distinct from *Belodon*, and to have, in all probability, belonged to Plieninger's Pachypode. This sagacious suggestion receives the strongest support from the subsequent discovery of the maxilla of *Megalosaurus**, which is extremely similar to that of *Teratosaurus* in all its important features, though, in some minor details, the two are sufficiently different to enable them to be clearly distinguished. Hence I think that, until evidence to the contrary appear, it will be well to adopt Von Meyer's suggestion, and speak of the skeletons as well as the jaw under the name of *Teratosaurus*.

In the course of his memoir (p. 415) Prof. Plieninger refers to the discovery of the remains of a large reptile in the Upper Keuper near Basle by Prof. Gressly, and states that he has reason for identifying it with his *Belodon* (i. e. *Teratosaurus*).

2. Dinosauria *from the Trias of Britain.*

I had got thus far in accumulating evidence of the existence of *Dinosauria* in the Trias of Europe, when, looking through the memoir by Riley and Stutchbury on the Saurian remains from the Bristol conglomerate, I was struck by the resemblance which some of the bones they figure present to those of *Dinosauria*. Most

* See Quart. Journn. Geol. Soc. vol. xxv. p. 311.

especially was this resemblance apparent in the so-called "coracoid" (fig. 11), which seemed obviously to be a Dinosaurian ilium—and in the femur, the likeness of which to that of *Megalosaurus* is noticed by the able authors of the memoir themselves, and it has been subsequently referred to by Professor Owen (Palæontology, 2nd ed. p. 278) as "a Dinosaurian femur." It seemed to be highly desirable that these fossils should be examined anew; and in consequence of a communication to Mr. Saunders, they were placed at my disposal in the most obliging and liberal manner. On visiting the Bristol Museum, more than a hundred different specimens were spread before me, and I was able to select from among them illustrations of the structure of the skeleton of almost every part of the body of the "*Thecodontosauria*," and to obtain proof that these singular reptiles were in all respects *Dinosauria*.

I hope to publish an account of these remains, with full details and illustrations, in the Memoirs of the Survey. For the present I confine myself to the bones which, taken together with those already described, demonstrate the Dinosaurian affinities of the Thecodonts, and determine the relations of the latter with other *Dinosauria*.

In their well-known memoir*, Messrs. Riley and Stutchbury founded the genus *Thecodontosaurus* upon an imperfect mandible, containing twenty-one teeth (which was apparently the total original number) in a series. These teeth, they say, are acutely pointed and flattened, and the anterior edge is curved backwards and serrated; the posterior edge is also slightly curved and strongly serrated, the serratures being directed towards the apex of the tooth. The middle teeth are the largest; and all the teeth possess a conical pulp-cavity (Pl. III. figs. 1 & 2). To a single specimen of a broadly lanceolate tooth, with serrations at right angles to the axis, they attach the name of *Palæosaurus platyodon*. Another solitary tooth of more elongated conical form they term *Palæosaurus cylindrodon*. The description of the teeth of *Thecodontosaurus* is perfectly accurate; but I can see no important difference, in the direction of the serrations or otherwise, between these and the tooth called *Palæosaurus platyodon*, which, I suspect, may belong simply to a larger *Thecodontosaurus*.

In the tooth termed *Palæosaurus cylindrodon*, on the other hand, the direction of the serrations is really at right angles to the axis of the tooth; and in its form, also, the tooth more resembles that of *Megalosaurus*, being elongated, with the posterior margin straight or slightly concave, while the anterior contour is convex. The sharp posterior median ridge of the tooth extends for the whole length of the crown, and is strongly serrated throughout. The anterior serrated ridge is visible in what remains of the upper part of the crown; but I am unable to trace it in the lower half of the front face of the enamel (Pl. III. fig. 3). I think it will be proper to

* "A description of fossil remains of three distinct Saurian animals recently discovered in the Magnesian conglomerate near Bristol, by Henry Riley, M.D., and Mr. Samuel Stutchbury, A.L.S.," read March 23rd, 1836.

restrict the name *Palæosaurus* to the latter (or Megalosauroid) form of tooth, and to use *Thecodontosaurus* for the former (or Scelidosauroid) type, the varieties of which may be embraced under the common name of *platyodon*.

The bones referred to and described by Riley and Stutchbury are vertebræ, ribs of two kinds, a clavicle, two "coracoids," a humerus, a "radius," two femora, an "ischium," a tibia, a fibula, metacarpal and metatarsal bones, and ungual phalanges.

The "coracoid" figured is, as I suspected, a fragmentary ilium. The "radius" I take to be a tibia. The parts of the skeleton which diagnose the Dinosaurian nature of these reptiles, in addition to the teeth, are:—1, a caudal vertebra with the chevron bone; 2, an ilium; 3, a tibia.

The diagnostic mark in the first part of the skeleton mentioned lies in the complete union of the crura of the chevron bones at their proximal ends, in consequence of which coalescence the fork of the chevron bone is converted into a foramen (Pl. III. figs. 5 & 6). This character appears to be universal among the *Dinosauria*.

With respect to the ilium (Pl. III. fig. 7), it has every character of that bone in the *Dinosauria*. That part which enters into the acetabulum forms a semicircular arch, the piers of which are formed by the præ- and postacetabular processes (*a*, *b*), both of which are strong and trihedral. They are about equal in length; and each ends in a truncated face, which looks a little downwards and a little forwards in the anterior, downwards and a little backwards in the posterior process. The expanded supraacetabular part of the ilium (*c*) is a vertically disposed plate, equal in height to the acetabular part. Anteriorly (*d*) it is produced in front of the acetabulum for a length equal to that of the neck by which it joins the acetabular part. Posteriorly (*e*) it is prolonged into only a very short process, which does not project as far backwards as the postacetabular apophysis.

In all these respects the Thecodontosaurian ilium exaggerates the peculiarities of that of *Megalosaurus*. And the like is true of the form of the outer and inner surfaces, and of the superior contour, of the supraacetabular part. In the Triassic Dinosaurian the outer surface of this part of the bone is strongly concave from before backwards above the acetabulum, the posterior iliac process being sharply bent outwards; while it becomes flat above the anterior iliac process. Hence the superior contour has a sort of ∫-like curve. The supraacetabular part of the ilium of *Megalosaurus* has the same curvature, though less strongly pronounced. The inferior surface of the anterior process of the supraacetabular part of the ilium of *Megalosaurus* presents a narrow groove, bounded on each side by ridges of bone. In the Thecodont, the place of the groove is taken by a broad surface which is only slightly concave from side to side. In *Megalosaurus* the posterior iliac process is a little longer than the postacetabular, and possesses a considerable height. In the Thecodont it is shorter, and much lower and more tapering posteriorly.

The proximal end of the tibia (Pl. III. fig. 8) possesses the great outwardly bent cnemial crest which is characteristic of that bone in the *Dinosauria*.

The ilia, femora, and tibiæ in the Bristol collection are all of one kind; and the question therefore arises, do they belong to *Thecodontosaurus* or to *Palæosaurus*? Considering that three sets of Thecodontosaurian teeth have been found for only a solitary Palæosaurian tooth, the probabilities would seem to be in favour of the bones belonging to *Thecodontosaurus*. But, on the other hand, the teeth of *Thecodontosaurus* are Scelidosaurian in character; and it seems to be hardly likely that these teeth should have accompanied hind limbs which are the reverse of Scelidosaurian, and exaggerate the peculiarities of those of *Megalosaurus*, when we have, in *Palæosaurus*, a tooth so like that of *Megalosaurus* that it is only distinguishable by critical examination. With the present materials I do not think any decision can be safely arrived at on this question, and I shall speak of the bones as those of Thecodontosaurians, without prejudice as to the particular genus to which they may belong.

I may observe, in conclusion, that the ilium is shorter in proportion to the femur in these Dinosauria than in any others with which I am acquainted, and that the cavities in the bones are so extraordinarily large and well defined that, if found alone, it would be hard to distinguish some of them from those of *Pterosauria*.

The Thecodontosaurians, then, are *Dinosauria*; but the question may be raised whether the conglomerate in which they are found is really Triassic, some geologists appearing to be inclined to think them of Rhætic age, while Von Meyer, as has been seen, looks upon them as transitional between Muschelkalk and Keuper*. It does not lie within my province to discuss this problem, the decision of which, either way, will not affect the occurrence of Dinosauria in the Trias; and I therefore pass on to examine into what evidence there may be of the existence of Dinosaurian reptiles in the Warwickshire sandstones, the Triassic age of which appears to be beyond question.

Many years ago certain teeth were discovered in these sandstones by Dr. Lloyd, and were placed by him in the hands of Professor Owen, who has thus described them in his 'Odontography,' which was published between the years 1841 and 1845:—

"In their compressed form, anterior and posterior serrated edges, sharp points, and microscopic structure, these teeth agree with those of the Saurian reptiles of the Bristol conglomerate. In their breadth, as compared with their length and thickness, they are intermediate between the *Thecodontosaurus* and the *Palæosaurus platyodon*. They are also larger and more recurved, and thus more nearly approach the form characteristic of the teeth of the *Megalosaurus*. From these teeth, however, they differ in their greater degree of compression and in a slight contraction of the base of the crown."

* On this question I refer the reader to a forthcoming paper by my colleague Mr. Etheridge.

Figures of these teeth, of the natural size, are given in plate 62 A, figs. 4 a & b, of the work cited.

I am at a loss to discover the smallest resemblance between these teeth and either those of *Thecodontosaurus* of Riley and Stutchbury or the so-called "*Palæosaurus*" *platyodon* tooth, which is represented in the same plate, fig. 7; nor can I divine in what sense the *Cladyodon* teeth can be said to be intermediate between the two. If they were affirmed to be intermediate between *Thecodontosaurus* and *Palæosaurus cylindrodon*, the statement would be intelligible, though I do not think it would be altogether accurate.

I have been favoured by Mr. T. G. B. Lloyd, F.G.S., with the opportunity of examining three Saurian teeth from the quarries which yielded *Cladyodon*. Two of these teeth (Pl. III. fig. 4) are so similar to those of *Palæosaurus cylindrodon* in form, and even in colour, that I conceive them to belong to the same genus, and perhaps to the same species, although they are twice as large as the teeth from Bristol. They show most distinctly the abrupt cessation of the anterior serrated ridge about halfway down the crown, which beneath this point is rounded and curved as in *Megalosaurus*. I see no reason to doubt that these are Dinosaurian teeth. Of the other tooth, only the crown, which is 1·8 inch long, is preserved (Pl. III. fig. 11). This tooth must have had, as nearly as may be, the same dimensions as the hindmost tooth in the upper jaw of the *Megalosaurus* figured in the 'Quarterly Journal' of this Society (vol. xxv. pl. 12); and if placed over that tooth it corresponds with it in contour with remarkable closeness. On the whole, however, the crown of the Megalosaurian tooth is thicker near the fang than the present tooth. But what distinguishes the latter at once from all the Megalosaurian teeth of which I have been able to obtain a sufficiently clear view, is the fact that the serrated anterior ridge extends along the whole length of the crown, instead of stopping short halfway from the apex, as it does in *Megalosaurus*. In this respect the tooth from the Trias resembles those of *Teratosaurus*; and it may possibly belong to that genus.

Thus it appears that there are two kinds of Dinosaurian teeth in the Warwickshire Trias—one kind allied to *Megalosaurus*, the other to *Thecodontosaurus*.

Thanks to Mr. Kirshaw, who has so skilfully worked out many of the fossils of the Warwickshire Trias, I am able to add new evidence which tends in the same direction. This consists of three consecutive vertebræ (Pl. III. fig. 9), which have been ankylosed together, though they are now separated by the breaking away of the greater part of the hinder portion of the second vertebra. The centra of these vertebræ are much constricted in the middle, while their articular surfaces are flat or slightly excavated (Pl. III. fig. 10). The bones have been so much distorted and crushed that it is hard to say what the contour of these surfaces may have been; but they were either circular or oval, the long axis of the ellipse being vertical. The spinous processes are broken away. The faces of the præzygapophyses look inwards as well as upwards, so as to embrace the postzygapo-

physyses of the antecedent vertebra laterally. The postzygapophyses of the first vertebra are completely ankylosed with those of the second; and those of the second seem to have been similarly united with those of the third. The centrum of the first vertebra, on the other hand, is not absolutely fused with that of the second, the separation being everywhere traceable; and the union between the centra of the second and third vertebræ seems to have been still more lax. Each neural arch is connected only with its own centrum, and the intervertebral foramen lies over the posterior moiety of each centrum.

A strong, prismatic sacral rib with a triangular section, only the proximal end of which remains, springs from the junction of the centrum with the neural arch on each side, in the first vertebra, and appears to have been directed perpendicularly outwards. The second vertebra seems to have possessed a similar rib, which, however, springs rather further back from the anterior edge of the arch. The third vertebra also possesses a strong rib, the root of which occupies the middle of the arch. The contour of the broken end of the rib is more nearly four-sided. The anterior and posterior faces are concave from above downwards, and are directed obliquely, the anterior upwards, and the posterior downwards. The centrum of the anterior vertebra is 1·6 inch long, that of the third 1·75 inch; but the difference may be the result of the crushing of the vertebræ, which are a good deal distorted. The height of the centrum seems to have been about 1·3 inch, the width about 1·1 inch.

Mr. Kirshaw has sent me two centra of vertebræ, which may very well have belonged to the same animal as the sacrum. One of these is almost undistorted, and belongs to the dorsal region. It is 1·6 inch long; and the better-preserved articular surface is 1·55 inch high, while its greatest width is rather less than 1 inch. The surface is very slightly concave, and is perpendicular to the axis of the centrum. The centrum is much constricted, so as to be not more than 0·6 inch wide in the middle; and, as in the other vertebræ, the floor of the neural canal sinks rapidly from each end towards the middle of the centrum. Some of the vertebræ from the Bristol conglomerate bear an extraordinarily close resemblance to these.

The fragmentary vertebra described and figured by Professor Owen as belonging to *Labyrinthodon pachygnathus* has the same general characters as those now described. The vertebra ascribed to *Labyrinthodon leptognathus*, on the other hand, appears to have belonged to some other reptile.

The remarkable ilium ascribed to *Labyrinthodon pachygnathus* (*l. c.* pl. 45. figs. 16, 17) is also a reptilian bone, intermediate in its characters between the ilium of a Teleosaurian and that of a Lizard. It is very similar to an ilium from the Keuper described and figured by Von Meyer ('Palæontographica,' Bd. vii. pl. 41), and ascribed by him to *Belodon*. I propose to discuss the nature and signification of this remarkable bone in another communication.

I have no direct evidence of the presence of *Dinosauria* in the Elgin sandstones; but ample proof is in my possession that the

cast of a mandible, which I have described ('Quarterly Journal of the Geological Society,' 1858, vol. xv. p. 454) as probably appertaining to *Stagonolepis*, did not belong to that reptile, the teeth of which possess short and comparatively obtuse crowns. I think it more than probable that this mandible, with its great recurved and pointed teeth, which had large pulp-cavities and were implanted in distinct alveoli, may have belonged to a Dinosaurian reptile.

I know of no further evidence of the existence of *Dinosauria* in rocks of Triassic age in Western Europe than that which I have now brought forward; but it is sufficient to demonstrate the existence of, at fewest, two genera in the German Trias, and of three in that of Britain.

3. DINOSAURIA *from the Trias of the Ural Mountains and India.*

In the extreme east of Europe, namely in the Ural Mountains, there is a series of rocks which have been supposed to be Permian, but which there now appears to be every reason to consider to be of Triassic age. Remains of reptiles associated with those of Labyrinthodonts from these rocks have been described and figured by D'Eichwald ('Lethæa Rossica') and by Von Meyer (Palæontographica, Bd. xv.). Now the teeth and jaws of the *Deuterosaurus* of D'Eichwald, no less than the vertebræ which are referred to the same genus by this author, have a strongly Dinosaurian aspect; and though the evidence is incomplete, I am greatly inclined to think that *Deuterosaurus* is a Dinosaurian. But the specially interesting feature of the Ural Triassic fauna is the association with the Labyrinthodonts and possible *Dinosauria*, of the *Rhopalodon*, so singular for its great canine tusks, in front of and behind which were comparatively small "incisors" and "molars;" for no one who compares *Rhopalodon* with the *Galesaurus* of Prof. Owen, from the Dicynodont-yielding sandstones of South Africa, can fail to see that the two forms are closely allied.

On the other hand, Von Meyer describes humeri and portions of crania from the same deposits, the nearest resemblance to which he finds in the corresponding parts of the skeleton of *Dicynodon* itself. Thus there is a clear affinity between the Triassic fauna of the Ural and that of South Africa. But in the Ural we have reached a point halfway between the West of England and Central India. I have already ("Palæontologica Indica," in 'Memoirs of the Geological Survey of India,' 1865) shown reason for the belief that the Central-Indian and the African faunæ of the "Poikilitic" period were closely allied; and I have described a small Thecodont Saurian (*Ankistrodon*) from the Indian beds. Thanks to Professor Oldham (the Director of the Indian Survey), I am now enabled to go a step further; for among the remains which last reached me from him there are portions of a Crocodilian closely allied to *Belodon*; and thus the Indian fauna, together with that of the Ural, binds the Triassic fauna of Western Europe with that of Africa*.

* A fragment of a jaw from Malédi reminds me forcibly of *Rhopalodon*.

4. Dinosauria *from the Trias of North America.*

The Trias of North America has yielded the remains of two forms of reptiles, *Clepsysaurus* and *Bathygnathus**. The teeth, jaw-fragments, and vertebræ of these reptiles have characters which are quite in accordance with those of the *Dinosauria*, to which group they have lately been referred by Cope and Leidy, and I entertain no doubt that they are *Dinosauria*; but, unfortunately, none of the remains which have been discovered belong to what may be called *diagnostic* bones, such as the ilium, the femur, or the tibia.

5. *The Arctogæal province constituted in Triassic times.*

Assuming, provisionally, that these reptiles are *Dinosauria*, the distribution of that group and of the other *Reptilia* and *Amphibia* of the Trias may be tabulated in the annexed form.

Putting together all the facts now ascertained respecting the distribution of the "Poikilitic" *Reptilia*, I think that the horizon of all these beds tends to become definitely Triassic rather than Permian.

And, in conclusion, I may draw attention once

	North America.	Britain.	Germany.	Ural Mountains.	Central India.	South Africa.
Reptilia—						
Crocodilia	....	Stagonolepis.	Belodon.	....	Parasuchus.	Pristerodon?
Dinosauria	Clepsysaurus, Bathygnathus.	Thecodontosaurus, Teratosaurus, Palæosaurus, Cladyodon.	Palæosaurus, Teratosaurus, Zanclodon?	Deuterosaurus, Rhopalodon?	Ankistrodon.	
Dicynodontia ...	....	....	....	....	Dicynodon.	Galesaurus? Dicynodon, Oudenodon.
Placodontia	....	....	Placodus.			
Lacertilia	....	Hyperodapedon, Telerpeton, Rhynchosaurus.	....	....	Hyperodapedon.	Saurosternon.
Plesiosauria	....	....	Nothosaurus, Pistosaurus, Simosaurus, &c.			
Ichthyosauria ...	....	....	Ichthyosaurus?			
Amphibia—						
Labyrinthodontia	....	Labyrinthodon.	Labyrinthodon, Mastodonsaurus, Metopias, Trematosaurus, Capitosaurus.	Melosaurus, Zygosaurus, Chalcosaurus.	Gonioglyptus, Pachygonia.	Micropholis.

* See the memoirs by Lea and Leidy in the second volume of the second series of the 'Journal of the Academy of Natural Sciences.'

more to the very remarkable fact, that, so far as the present evidence goes, the dry land of those Triassic epochs was as extensive in the old and northern New World as it is at the present day, and that, just as the mammalian and ornithic faunæ of these regions lead us to group North America, Europe, Asia, and South Africa in one vast Arctogæal province, so the affinities of the land reptiles of the Trias lead to the conclusion that at that epoch the same regions constituted a similar great distributional area.

EXPLANATION OF PLATES I.–III.

Plate I.

Fig. 1. The skull of *Hypsilophodon Foxii*, of the natural size.
Pa, parietal; *Fr*, frontal; *Na*, nasal; *Pmx*, præmaxilla; *La*, lacrymal; *Mn*, mandible; *a*, prælacrymal vacuity; *b*, suture between the præmaxillary and maxillary bones; *N*, nasal aperture; *c*, centrum of a vertebra.
2. A molar tooth, and
3. An incisor tooth, magnified.
4. The left ramus of the mandible: *Qu*, the quadrate bone; *a*, the coronoid process.
5. The left præmaxilla. In this figure and in fig. 1. the line from *Pmx* leads to the edentulous prolongation.
6. Side view of a caudal vertebra, of the size of nature.
7. End view of another caudal vertebra.
8. A chevron bone, of the natural size.

Plate II.

The pelvis of *Hypsilophodon Foxii*, two-thirds the natural size.
a, the anterior, *b*. the posterior extremity of the right ilium; *Is. Is.* the right and left ischia; *Pb.* the pubis.

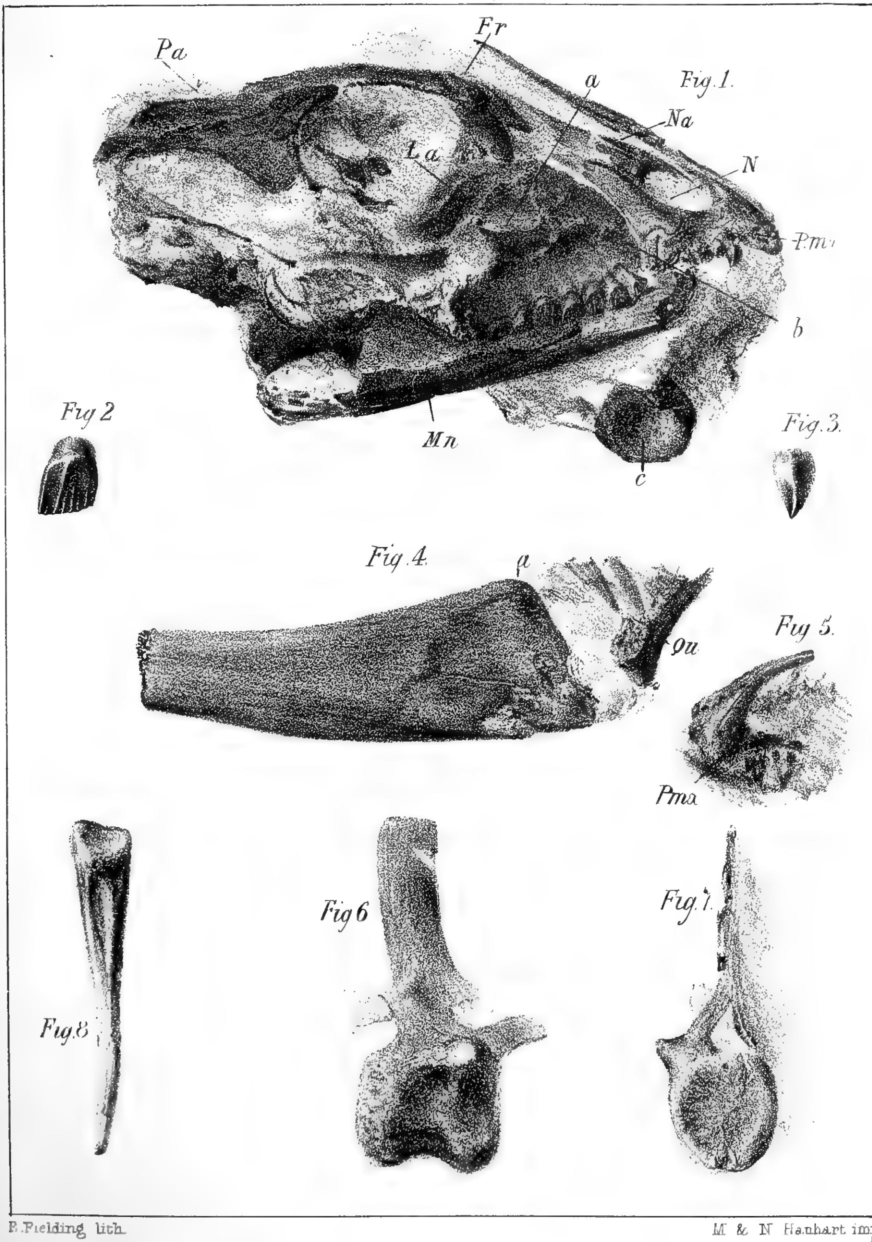
Plate III.

Fig. 1. The dentary portion of the left ramus of the mandible of *Thecodontosaurus*.
2. One of the teeth of *Thecodontosaurus*, magnified three times.
3. The typical specimen of the tooth of *Palæosaurus cylindrodon*, magnified three times.
4. One of the teeth of the Warwickshire *Palæosaurus*.
5. A caudal vertebra of *Thecodontosaurus* (?) with its chevron bone, which is imperfect below.
6. The anterior aspect of the same chevron bone.
7. The inner face of the right ilium of *Thecodontosaurus* (?).
8. The proximal end of the right tibia of *Thecodontosaurus*.
9. The three sacral vertebræ from the Warwickshire Trias.
10. End view of the anterior vertebra of the sacral series (fig. 9).
11. *A*. anterior view, *B*. lateral view, of the tooth from the Warwickshire Trias which probably belongs to *Teratosaurus*.

Discussion.

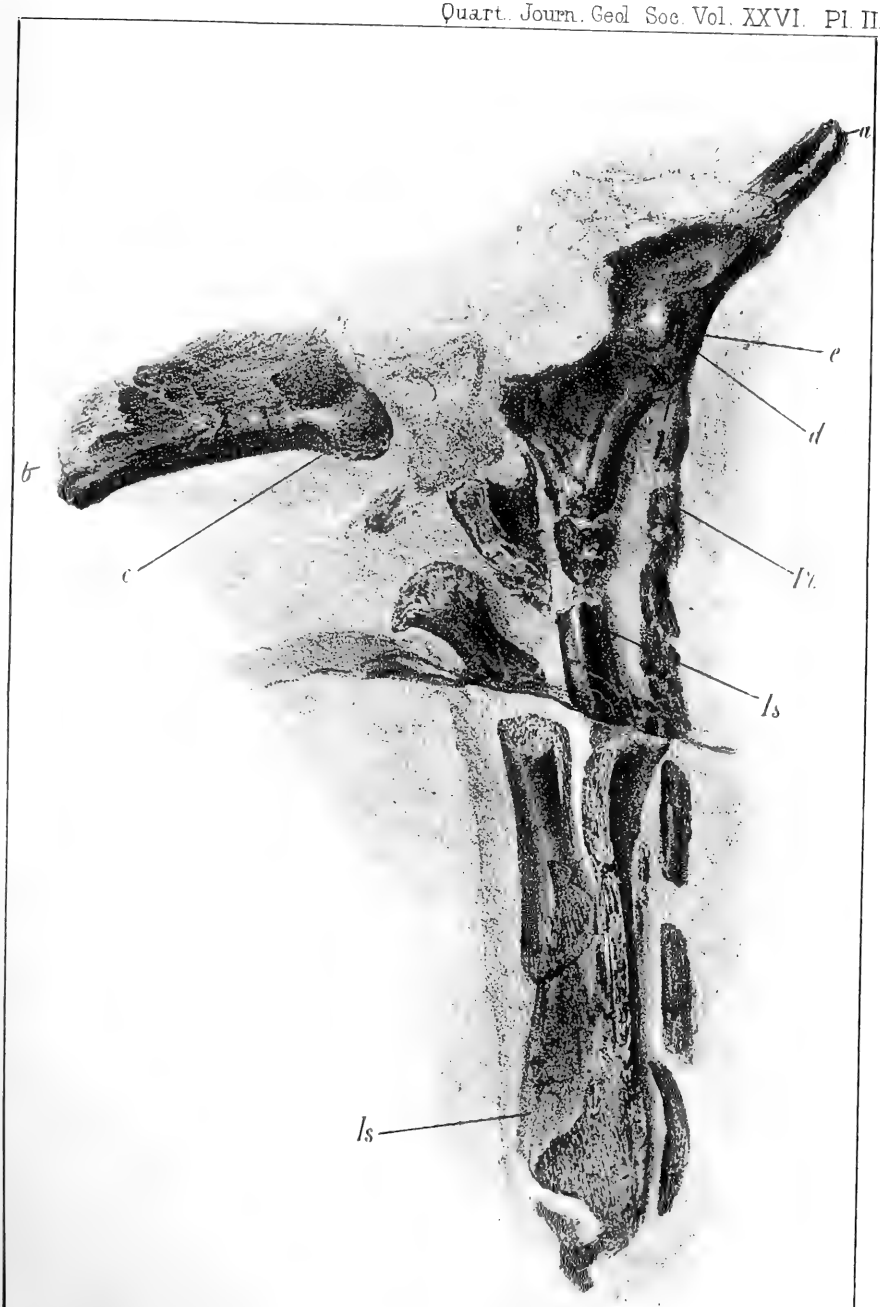
Sir Roderick Murchison, who had taken the Chair, inquired as to the lowest formation in which the bird-like character of Dinosaurians was apparent, and was informed that it was to be recognized as low as the Trias, if not lower.

Mr. Seeley insisted on the necessity of defining the common plan both of the Reptilia and of the ordinal groups before they could be treated of in classification. He had come to conclusions as to the grouping and classification of Saurians somewhat different from



B. Fielding lith. M & N Hanhart imp.

HYPSILOPHODON FOXII.



R. Fielding lith

M & N Hanhart imp.

HYPSILOPHODON FOXII.

those adopted by the President. This would be evident, so far as concerned Pterodactyles, from a work on Ornithosauria which he had just completed, and which would be published in a few days.

Mr. ETHERIDGE stated that the dolomitic conglomerate in which the Thecodont remains occurred near Bristol was distinctly at the base of the Keuper of the Bristol area, being beneath the sandstones and marls which underlie the Rhætic series. There were no Permian beds in the area. He regarded the conglomerates as probably equivalent to the Muschelkalk. It was only at one point, near Clifton, that the Thecodont remains had been found.

Prof. HUXLEY was pleased to find that there was such a diversity of opinion between Mr. Seeley and himself, as it was by discussion of opposite views that the truth was to be attained. He accepted Mr. Etheridge's statement as to the age of the Bristol beds.

---

2. *The* PHYSICAL GEOGRAPHY *of* WESTERN EUROPE *during the* MESOZOIC *and* CAINOZOIC *periods elucidated by their* CORAL FAUNAS. By P. MARTIN DUNCAN, M.B.Lond., F.R.S., Sec.G.S.

CONTENTS.

I. INTRODUCTION.

THE physical conditions which determine and accompany the existence of coral reefs, and the natural history of those vast aggregations of species of Madreporaria, have been sedulously and successfully studied ever since Darwin and Dana published the facts and theories which aroused the scientific world to a sense of their importance to geological reasoning. The physical geography of the Indo-Pacific and West-Indian seas has been investigated with as much care as the zoology of those marine banks which, fashioned by coral polypes, form a nidus for the existence of vast numbers of Invertebrata, fish, and birds. Nothing has been more satisfactorily determined than the scheme of the production of reefs, and the system of species-grouping that obtains in them.

The dependence of the coral polypes upon certain definite external conditions is as well understood as is that of the myriads of mollusca upon the flourishing state of the reef-builders. The dredge * has done much to show the characters of the corals in the shallows and moderately deep seas of reef areas; and the species and genera frequenting them have been distinguished from those peculiar to the

* The late Mr. Christy gave me the results of his dredgings of Corals between Cuba and Jamaica Pourtales, Bull. Mus. Harvard Coll. nos. 6, & 7.

reefs and lagoons. The bathymetrical disposition of the species of the reefs has been studied with good results *; and it has become evident that there are natural-history provinces of Madreporaria, the most distinct being those of the Caribbean sea and the Indo-Pacific Ocean.

Careful and systematic dredging in the Mediterranean, the North Sea, and the Atlantic has proved the existence of a deep-sea and abyssal, as well as of littoral coral faunas, which have nothing in common with true reef forms. The anatomical construction of the majority of the deep-sea corals differs from that of the reef-builders and the species inhabiting shallows and lagoons in the neighbourhood of reefs. There are evident distinctions in the methods of growth and gemmation. The physical conditions of the areas are as diverse as the genera and species inhabiting them.

The corals of the West Indies, Bermudas, Indo-Pacific, South Sea, China seas, and Red Sea, form one series; and the species inhabiting the deep water and littoral tracts off some portions of the great continents are included in a second. The species of the first are infinitely more numerous than those of the second series, and there is no difficulty in distinguishing them. The external conditions which accompany both series are tolerably well understood; and the instability of reef areas is comparable with the stability of the deep seas beyond their range. Recent researches have proved that vast districts of the deep-sea bottom are uncoralliferous, and that others maintain much coral life at immense depths †.

Whilst the natural history of the existing Madreporaria has been carefully studied, the palæontology of the coralliferous strata has been by no means neglected. Monographs, properly illustrated, have described the fossil corals of certain districts; and systematic works have treated of the fossil Zoantharia as a whole. Reuss's descriptions of the corals of the Oberburg in Styria, Castel Gomberto in the Vicentin, and Gosau in Austria ‡, are as exhaustive as the labours of d'Achiardi §, Seguenza ||, De Fromentel ¶, and, last, but not least, of MM. Milne-Edwards and Jules Haime **.

The description of the fossil corals of the Mesozoic and Cainozoic strata of Great Britain has been completed ††, and the relation of the successive coral faunas in them to those of the equivalent formations of the Continent has been studied and noticed. In fact, the literature of the coral formations is sufficiently advanced for some generalizations to be attempted between the peculiarities of the past and present faunas.

* Michelotti and Duchassaing, Mem. dell' Accad. Torino, 1865. Lyell, Principles of Geology, 1868.

† Reports on deep-sea dredging (Proc. Roy. Soc. 1869), Carpenter, W. Thomson, Gwyn Jeffreys.

‡ Essays in Wien. Akad. Denkschr.

§ Coral. Foss. in Mem. della Soc. Ital. di Sci. Nat.

|| Coral. Foss. in Mem. della Reale Accad. Torino, Serie ii. tomo xxi. p. 399.

¶ Polyp. Fossiles.

** Pal. Soc. Brit. Foss. Corals. Hist. Nat. des Corall.

†† Duncan, Pal. Soc. Brit. Foss. Corals.

There has been much progress made in connecting the phenomena of existing reefs with those of the past, with the idea of establishing propositions upon which geologists could reason. Many years since, Lieut. Nelson* proved that sediments which were supposed to be characteristic of Oolitic and Cretaceous rocks were imitated around the Bermudas; and of late years much has been written upon coral limestones and marls, and the metamorphosis of coral rocks into dolomites has been hinted at †.

Speculations have also been published respecting the influence of the subsidence of reefs, their becoming covered up with deep-sea deposit, and the creeping of deep seas over littoral tracts and land upon the notions of contemporaneity ‡.

In 1863 § the similarity in general arrangement of the Miocene reefs of the West Indies to those now encircling many of the islands was announced; and it was stated that the species of the old reefs could be divided into those which lived amongst the boiling surf, in the quiet lagoon, along a barrier reef, and in deep water close by. The raised reefs of San Domingo were shown to link the specialities of existing reefs to those of the past; and an examination of still older coral formations on the same area indicated that even in the Lower Cretaceous rocks there were proofs that the same external conditions and the same grouping of coral forms were as characteristic of the ancient as of the Caribbean reefs.

Again, the study of the Sicilian and Crag deposits proved that the former seas, out of the range of reefs, had coral species representative of those now living in deep and abyssal water, and occasionally just below low spring-tide mark.

Moreover many English geologists ‖ had shown that coral reefs formed parts of Palæozoic and Oolitic landscapes; and Stoppani ¶ proved that the Azzarolan banks were formed by a branching Madreporarian.

With these facts and theories at hand there is a demand for their utilization in some common inquiry; and this communication is an attempt to explain some of the former physical conditions of Western Europe by comparing the fossil coral faunas with the existing**.

It commences with a notice and a description of the typical species of the coral fauna of the deep and abyssal seas which bound continents remote from reef areas; and then follow remarks upon

* Trans. Geol. Soc. 2nd ser. vol. v.

† S. P. Woodward held this opinion. (Geol. Mag. vol. i. "Review of the Dolomite Mountains.")

‡ Duncan, Report on Brit. Foss. Corals, Brit. Assoc. 1868, 1869.

§ Quart. Journ. Geol. Soc. vol. xix. p. 406.

‖ Ramsay and Murchison; Wright, Cotteswold Club, 1868.

¶ Pal. Lombard.

** Some theoretical considerations bearing upon this communication will be noticed in :—Description Foss. Corals of the West India Islands, 1863. Report on British Fossil Corals, read at Norwich, 1868, and Exeter, 1869. Palæontograph. Soc. Supp. Brit. Foss. Corals, 1865. Tertiary (written 1864). Since this essay was read the specimens of corals dredged up in the 'Porcupine' expedition have been examined by me, and Count Pourtales has sent me most of the types of the deep-sea coral fauna off Florida and the Havannah. I still find that the deep-sea coral faunas differ essentially from those of coral-reef areas.

the littoral corals. The peculiarities of reef, lagoon, and shallow-water species, and the relations of the two faunas to each other are then explained. The exceptional species are considered, and a typical list of genera whose species form existing reefs and contributed to those of the past is given. The representatives of some of the modern genera in old reefs are noticed, and then the essential principles of the line of argument are stated. For instance the correspondency of physical conditions during the deposition of strata containing analogous forms, the presence of compound cœnenchymal species indicating neighbouring reefs, and their absence in places where simple or non-cœnenchymal Madreporaria are found, being characteristic of deep-sea areas which were remote from coral-seas. The physical conditions of the seas of Western Europe from the Trias to the present time are considered, and the geographical peculiarities now witnessed in association with reef and deep-sea areas are briefly referred to.

The details which ought to be comprised in a perfect essay upon this subject are so enormous in amount that I have considered it best to offer this paper merely as a "mémoire pour servir;" and it is to be hoped that further researches, especially in the deep seas between and beyond the remote islands of the Pacific coral-sea, will clear up some doubtful points.

II. Deep-sea and Abyssal Corals (existing).

Many species of Madreporaria flourish at considerable depths in the seas of Western Europe. The Mediterranean Sea, the Atlantic off the coasts of Spain, France, and Ireland, and the North Sea between the Shetlands and the coast of Norway have yielded to the dredger simple, dendroid, and bush-shaped stony corals at depths of from ten to many hundred fathoms.

These European species have representatives in the deep seas off long lines of continent in many parts of the world. Such forms are sparsely distributed off the western and south-eastern coasts of Africa, the northern sea-board of the United States, and the west coast of the Isthmus of Panama, and they have been met with in the North China Sea and off the coasts of New Zealand and South Australia.

There is a close resemblance in shape and in minute construction amongst these deep-sea corals. Some of the species have great ranges in depth and in area, whilst others are restricted to certain spots. They are never found constituting coral reefs; and but few of the genera to which they belong have contributed forms to the faunas of those aggregations of Madreporaria, or to those of the shallow waters in and about them.

The deep-sea corals are not distributed universally over the sea-bottom. Some places are not coralliferous, and others are crowded with individuals of all sizes of one or more species. All of them are restricted to those portions of the sea-bottom which are remote from the entrance of large rivers, and from flat muddy shores, and which are not in the line of rolling pebbles, where conglomerates can form, or of such sediments as would constantly cover the polypes

with fetid mud. The branching, bush-shaped and dendroid forms are usually found upon a rocky bottom; and the simple corals generally select a shelly foundation or a foraminiferous ooze.

The genus whose species are dwellers in the deep sea, and which is most familiar to European naturalists, is *Caryophyllia*. It is a genus whose species are invariably simple in form or solitary; they reproduce by ova alone, and do not form a compound corallum by gemmation.

Alphonse Milne-Edwards * obtained numerous specimens of varieties of the Mediterranean *Caryophyllia arcuata* and *Caryophyllia clavus* from a depth of between 2000 and 2800 metres (1110 and 1550 fathoms) in the sea between Corsica and Algiers. Edward Forbes and others, since his time, have obtained *Caryophyllia cyathus* from a depth of from 5 to 200 fathoms. *Caryophyllia borealis*, Fleming, has been dredged up by Messrs. MacAndrew, Norman, and Gwyn Jeffreys in corresponding depths in the North Sea; Mr. Norman dredged up thousands in one spot in 70 fathoms; and therefore the species may be considered a common one over the coralliferous area of the western European seas.

The genus *Balanophyllia* has species in the Mediterranean at 80 fathoms; and Mr. Gwyn Jeffreys has found one at 340 fathoms, off the south-west of Ireland. Species of it are found in the deep seas off nearly every part of the world that has been mentioned as having a neighbouring deep-sea coral fauna.

Flabellum has a species (*Flabellum anthophyllum*) in the Mediterranean, in the Bay of Biscay, and in the North Sea; and others are found at considerable depths amongst the remote deep-sea faunas.

The Nullipore zone of the Mediterranean is inhabited by a species of *Desmophyllum*, which is found in deep water off Madeira and Cape Breton. Others have been found off Japan, and in the Pacific off the south-west coast of America.

There is a species of *Paracyathus* which is found at a depth of from 30 to 40 fathoms in the Shetland seas; and the genus is represented in the deep-sea fauna of the Mediterranean.

The genus *Sphenotrochus* has species in deep water off the Cornish coast, the west coast of Ireland, and near the Isle of Arran.

These are the typical deep-sea simple corals. None of them throw forth buds, and they all vary much in shape; the depth of water and the nature of the sea-bottom have much to do with the peculiarities of some forms.

The other deep-sea corals are compound Madreporaria. The great branching *Lophohelia prolifera* lives at a great depth in the North Sea, at more than 400 fathoms on rocky ground off the south-west coast of Ireland †, and in deep water in the Mediterranean. This is a typical deep-sea form; and the absence of the cellular cœnenchyma is, with one exception, a characteristic of the deep-sea compound corals, just as its presence is almost invariable in the species of the reef fauna. A huge branching coral, *Dendrophyllia*

* Mém. Acad. des Sci. July 1861. Ann. des Sci. Nat. tome xv. 1861.

† J. Gwyn Jeffreys's Report.

ramea, is often dredged up off Madeira, and in deep water off Cadiz. A second species is found in the Gulf of Gascony.

Amphihelia oculata, Linnæus, is found at great depths in the Mediterranean Sea and in the Atlantic south of the Faroe Islands; and there is a species in the Australian seas. *Cœnocyathus* and *Cladocora* have species amongst the deep-sea Mediterranean forms; and a species of this last genus is found off Madeira.

There are some genera which are characterized by a budding from an expansion of the base of the coral, or which throw out stolons. *Astrangia astræiformis* is a type of this family; and it is a moderately deep-water species off the eastern coast of the United States, north of the reef area.

Another form, *Cylicia tenella*, Dana, occurs in deep water off the south-eastern coast of Africa, and also near Australia; and allied species are found off the New-Zealand and Australian coasts.

There is a facies peculiar to these compound deep-sea corals, produced by their method of budding and growth, and by the absence of cellular cœnenchyma. When a collection of them is placed by the side of a series of specimens of reef-making corals, the distinction is very evident.

The habitats of these deep-sea species are rarely, if ever, invaded by the true reef forms*.

III. Exceptions.

There are deep-sea species of the genus *Stylaster*, Gray, (*Allopora*, Dana). Thus, *Stylaster flabelliformis*, Lamarck, sp., was found at a depth of 160 fathoms off the Isle de Bourbon. A closely allied species lives in deep water off the coast of Norway. These corals often have a cœnenchyma uniting the buds; but it is of the dense non-cellular structure which peculiarizes the family of the Oculinidæ, and not of the lax tissue which, with one exception, is seen in the ordinary reef corals.

The genus *Madracis*, which has deep-sea species off the Isle de Bourbon and Madeira, is an exception also; but the explanation just given suits its case.

IV. Littoral Corals belonging to the Deep-sea Coral Fauna.

Corals are occasionally found between low spring-tide mark and five fathoms, on the coasts of continents and large islands. Perfectly pure sea-water, freedom from muddy sediment and fresh water, a rocky bottom, and tolerably deep water close by appear necessary for their existence; and as these conditions are not to be found everywhere, the littoral corals are scarce. Vast tracts of the deep sea may be tolerably coralliferous, yet the nearest coasts are sparsely tenanted by a stunted coral fauna.

Considering the evidence which has been accumulating for years respecting the abundance of deep-sea Madreporaria in some parts of the Mediterranean and the Western seas of Europe already men-

* Count de Pourtales, Bull. Mus. Harvard Coll. nos. 6 and 7. The *Stylasteres*, *Errinæ*, *Cryptheliæ*, *Haplophylliæ*, and *Thecopsammiæ*, &c. described by him are deep-sea dwellers in and near a reef area.

tioned, it is remarkable how few species and individuals of them have been discovered to be dwellers in shallow water*. It is doubtful whether any of the littoral corals now under consideration are specifically distinct from those of the neighbouring deep water.

Edward Forbes found the deep-sea Mediterranean *Cladocora* in shallow water on the Ægean shores. Mr. Gwyn Jeffreys, Mr. Norman, and I agree that the stunted *Caryophyllia Smithii*, of the Cornish and Devonshire coasts, is a variety of the deep-sea form *Caryophyllia borealis*. *Balanophyllia regia*, Gosse, which is found with the littoral *Caryophyllia*, is closely allied to a deep-water species; and *Desmophyllum* has a littoral species very closely allied to the Mediterranean kinds.

The littoral simple corals are usually very small and stunted, and generally have broad bases, which are attached to stones or shells.

V. Corals forming Reefs of all kinds and inhabiting the Lagoons and shallow Seas in Coral-tracts.

The bulk of the species of Madreporaria are included amongst these; and the reef-builders may be recognized, for the most part, by their peculiar construction. Simple corals are rare, belong to different genera and families from those which are typical of the deep-sea fauna already noticed, and usually have a very well developed system of endothecal structures, which enable the polypes to grow rapidly.

The rest of the fauna is composed of compound corals, which increase by gemmation—the buds being usually united by a lax cœnenchyma or by their walls,—by fissiparous growth with or without budding, and by serial growth, which is an endless repetition of the mesenteric laminæ in definite directions. These structural peculiarities enable individual polypes to grow rapidly, to form aggregations, and to combine strength with an endless power of reproduction and repair. They enable the fragile-looking reef-builders to withstand the full force of the waves, and they promote the formation of coral limestone, after the death of the polypes, in consequence of the porous nature of the cœnenchyma. Moreover the methods of growth enable the reef, lagoon, and shallow-sea forms to carry out their technology in nature rapidly and surely.

It is not intended to describe reefs in this communication; for the information concerning them and the coral-seas can readily be obtained from the original source†. It must suffice to assert that many families of the Madreporaria contribute to the formation of reefs, and that there are species peculiar to different portions of the structures as well as to different depths in the lagoons and shallows. But they all have a general resemblance, and their method of reproduction and growth distinguishes them from the corals of the deep seas out of the range of reef areas, which have been already noticed.

VI. Exceptions.

Reef species straggle into the littoral tracts of continents near reef areas. Thus a *Pocillopora* of the Red Sea is common in 2 fathoms

* See Gosse, 'Actinologia Britannica,' for information concerning the littoral and deep-sea corals of our area.

† Darwin, Coral Reefs.

water at Aden. A *Manicina* of the Caribbean is found on the coast of Brazil. Mr. Darwin has given me some deep-sea corals from Cape Verde, and one is identical with a species found in the shallow sea between Cuba and Jamaica. *Plesiastræa* has species at Panama and Port Jackson. Rocks are often incrusted with reef corals—at Zanzibar and Ceylon for instance.

These exceptions are all within the range of the external conditions favourable for the existence of reefs, and the species retain the structural peculiarities which differentiate them from the deep-sea corals noticed at the commencement of this essay.

VII. Exceptional Relations of the two Faunas.

The genus *Flabellum*, which has species in the deep seas of western Europe, has others in the deep seas between the coral archipelago and the Asiatic continent, and some which are found in the reefs of the Fidji and other islands. There is a *Desmophyllum* in the West-Indian coral area, and *Caryophylliæ* also. *Dendrophyllia* has a species in the China seas within the range of the conditions favourable for reefs.

There is no well-established instance of any species or variety known to belong to the true coral fauna of reefs, lagoons, and shallows, within the range of the coral seas, which can be identified with any member of the deep-sea coral fauna of the offing of continents and large islands remote from the coral tracts.

As yet nothing is known about the corals of the depths between the coral islands of the Pacific Ocean, or of the inhabitants of the great sea-desert to the west of America; but Mr. Christy gave me a collection of corals he had dredged up between Cuba and Jamaica in not very deep water, and I found the species to be closely allied to and identical with those of the lagoons of the reefs*.

From what is known at present, then, the existence of two coral faunas must be admitted—one restricted to large portions of the world, where the conditions favourable for reefs exist, and the other confined to the littoral tracts, and deep and abyssal seas near certain continents. Both depend upon the persistence of definite external conditions, and neither could flourish on each other's area or in such seas as the Baltic or the Black Sea†.

It must be remembered, however, that coral reefs are not invariably found where the physical conditions which accompany them elsewhere exist. The few islands in the Atlantic are not surrounded by reefs, probably on account of the impossibility of the migration of Madeporarian ova to them. The Bermudas are exceptions; but their position in reference to the Gulf-stream explains their having a coral fauna of the reef kind.

When the details of the marine deposits of the Mesozoic and Cainozoic strata are studied, it becomes evident that some of them contain fossil corals belonging (so far as can be judged from the

* Consult Pourtales, *op. cit.*

† The abyssal fauna exists off Florida, and enters the reef area. See Pourtales, *op. cit.*

analogies of their structures and specific affinities) either to the deep-sea or to the reef fauna. When the fossils are evidently not derived from older strata, and not rolled or drifted, their having once lived on the area of their fossilization must be conceded.

If the general arrangement and grouping of forms peculiar to the reefs of the existing seas is evidently to be traced in those of the Mid-tertiary age, it is logical to admit that the very definite physical conditions peculiar to modern reefs existed formerly. This general arrangement may be instanced in the vast coral strata of the Nummulitic age; and the reefs of that period cannot be distinguished by the shape of the species from the coral remains of the Gosau reef area, or those of the Neocomian and the Oolites.

Still earlier in the world's history, the nature of the coral faunas may be estimated by scantily dispersed specimens which possess the peculiarities of one or other of the types.

The relation of high land, older strata, and intrusive rocks, their drainage, vegetation, and fauna to coral reefs may be learned in most works on physical geography and on the principles of geology*; and there is a possibility, which depends upon the imagination of the geologist, of forming ideal landscapes whenever corals abound in strata.

VIII. Genera of Reef-Faunas, Ancient and Modern.

The following is a List of Genera whose species form the existing and also composed some of the Tertiary and Mesozoic reefs.

Euphyllia.	Diploria.	Astræa.	Porites.
Barysmilia.	Leptoria.	Prionastræa.	Alveopora.
Pectinia.	Cœloria.	Agaricia.	Pocillopora.
Galaxea.	Hydnophora.	Pachyseris.	Millepora.
Stephanocœnia.	Favia.	Mycedium.	Heliopora.
Symphyllia.	Heliastræa.	Madrepora.	Cycloseris.
Mycetophyllia.	Brachyphyllia.	Turbinaria.	Trochoseris.
Ulophyllia.	Cyphastræa.	Astræopora.	Lithophyllia.
Mæandrina.	Solenastræa.		

Many of the genera are allied to other fossil forms with which they were associated; and by comparing and enumerating the extinct genera which lived with those whose species still exist, an extended list of reef-makers can be obtained. Such genera as *Pachygyra*, *Rhipidogyra*, *Astrocœnia*, *Phyllocœnia*, *Calamophyllia*, *Rhabdophyllia*, *Montlivaltia*, *Thecosmilia*, *Cladophyllia*, *Latimœandra*, and *Thamnastrœa* were associated with many of those in the list given above in the reefs of the Miocene, the Nummulitic, the Lower Chalk, the Neocomian, and the Oolitic periods.

The genera characteristic of the deep sea, and whose species do not form reefs, may be very well represented by the following list:—the genera of the families Turbinolides, Oculinides, many Trochosmiliaceæ, Lithophylliaceæ simplices, Cladocoraceæ, Eupsammiaceæ, and some Fungiaceæ.

IX. Coral-sea Conditions in different Periods.

The following is a list of the geological periods, showing the rela-

* Lyell; Dana; Jukes.

tive condition of the coral tracts of England and the rest of western Europe. No attention is paid to the existence of land masses.

	Great Britain.			Western Europe.		
	Reefs.	Deep-sea.	Littoral.	Reefs.	Deep-sea.	Littoral.
Trias	...	Land	...	* *		
Rhætic	...	*	*	*		
Zone of A. planorbis ...	*R	*R	*R	*		
Zone of A. angulatus ...	*	*	*	*	*	*
Zone of A. Bucklandi ...	*R	...	...	...	*R	
Middle Lias ...	...	*	*	...	*	
Upper Lias......	...	*R	...	...	*R	
Inferior Oolite	*	...	...	*		
Middle ,,	*	...	...	*		
Coral rag	*	...	...	*		
Portland Oolite	*R	...	...	*		
Neocomian......	...	*	*	*R		
Gault	...	*	*	*R	*	*
Cenomanian ...	...	*	*	...	*	*
Lower Chalk ...	...	*	...	...		
Upper ,, ...		*	...	*	*	
Eocene	...	*	*R	*	*	
Oligocene	*	...	...	*	*	
Miocene	...	...	...	*	*	
Crag-Pliocene	...	*	*	*	*	*
Recent	...	*	*	R	*	*

R after an asterisk denotes the paucity of reefs or of deep-sea conditions.

X. Corals and Coralliferous Deposits in consecutive Geological Periods.

The Trias.

There are no vestiges of coralliferous deposits in the British Trias. Formed as a marine deposit, the almost unfossiliferous Triassic sandstones were land-surfaces, whilst there were corresponding tracts reaching far away to the south-east, and great coral-reef areas to the east of the Vosges. The depth of the marine deposits of the Muschelkalk is very great; and some of them contain compound Madreporaria and some simple forms. The reef origin of much of the dolomite may be inferred; and the general affinities of the corals of the Muschelkalk and the St.-Cassian deposits indicate successive reefs upon nearly the same area, an elevation of the sediments of the first-named strata having occurred intermediately.

Rhætic Series.

The subsidence of portions of the Triassic land surface in Britain accompanied the deposition of the *Avicula-contorta* beds and the White Lias. Some few stunted forms of littoral and deep-sea corals existed in the seas of the period in Great Britain. There were no reefs in our area; nor are there any evidences of such structures in Europe, except in the Lombardian Alps and to the north of Savoy.

The Azzarolan deposits on the Lake of Como* contain abundance

* Stoppani, *op. cit.*

of Madreporaria, including compound forms of reef species. A large coral bank, from 8 to 10 metres in thickness, runs obliquely through a vast depth of marine deposits, and it may be traced as far as the south side of the Lake of Geneva. The position of this bank, which is nearly composed of one species of coral, is such that it must have grown during a slow subsidence of the area. All these deposits contain fossils which are closely allied to the St-.Cassian forms; and some are identical species.

Lias.

1. Zone of *Ammonites planorbis* and its equivalents.—The corals of this zone in England belonged to reef-species; and it is therefore probable that some scattered reefs were formed on our area during the considerable alterations in depth which the *Ostrea* and *Ammonites* zones indicate. Probably the reefs of the Alpine area still continued.

2. Zone of *Ammonites angulatus*.—The formation of fringing reefs and coral banks took place in the Glamorganshire area *; and the mountain-limestone supported them. Other reefs were formed in the north about Skye, and eastwards in Worcestershire. In Lincolnshire there were deep-sea conditions, and they prevailed also in the north of Ireland. Sparsely distributed reefs and deep seas may be traced in Northern and Eastern France and into Germany. The reefs on the Lombardo-Alpine area persisted. It must be remembered that Triassic fish lived through the Rhætic period into the times when the deposits now being considered were forming, and that species of Triassic corals and mollusca formed part of their fauna. There were 61 † species of corals on the British area. It would appear that the seas were full of a very rich invertebrate fauna during this period, and that the British, French, Belgian, and northern Italian districts were reef-areas.

3. Zone of *Ammonites Bucklandi* (*bisulcatus*).—The reefs appear to have diminished, and to have been worn down, before the peculiar deposits containing this Ammonite were formed. In England, the remains of the scanty coral fauna of the reefs of this period are seen to cover up those of the reefs of the zone of *Ammonites angulatus* in Glamorganshire. The sea of the age of *Ammonites Bucklandi* contained a few of the molluscan species of the previous reefs; but the bulk of their coral fauna is not to be recognized in its deposits, even by allied species. The area of England was losing the external conditions which hitherto and since the Trias had been gradually becoming more and more favourable for reef-formation. The coralliferous deposits of Western Europe are as scanty in Madreporarian remains as those of England; and it therefore would appear that the reefs initiated during the Muschelkalk age had, after a long continuance, gradually broken up, the variation in their consecutive faunas having been slight.

The other divisions of the Lower Lias and those of the Middle

* Quart. Journ. Geol. Soc., Feb. 1867.

† Duncan, Pal. Soc. Monog. Liassic Corals, vol. xx.

Lias of England were formed under very variable bathymetrical conditions; and deposits of Ammonites, deep-sea corals, and clays follow each other. The great coralliferous deposits of Fenny Compton and Cherrington were isolated patches on a very uncoralliferous sea-bottom. The corals of these deposits have no affinities with those of reef-faunas which preceded them; and the coral fauna of the zone of *Ammonites angulatus* in Glamorganshire was not represented in them, but it was clearly reflected in the assemblage of forms which characterized the upper part of the Inferior Oolite. There are no evidences of reefs or of an abundant deep-sea coral area in western Europe during these times. During the deposition of the Upper Lias and the lower part of the Inferior Oolite, the whole of the area appears to have become nearly uncoralliferous.

The Oolitic Strata.

There are few geological data more evidently true than the occurrence of successive reefs on the same areas of England and Western Europe during the formation of the Oolites. The whole of those districts was occupied by a coral-sea, interspersed with reefs, lagoons, and their associated land; and the bathymetrical conditions which prevailed resembled those now peculiar to reef-areas. The variations in depth on the same portions of the space were very considerable, even during the existence of the same groups of associated species; and successive reefs which still form part of the landscape* are noticed to be separated by the detritus of former ones, by deep-sea deposits, and even by shallow-water formations. Although the character of the sea-bottom varied greatly over the whole space contemporaneously and successively, the general characters of a coral-sea constantly prevailed; and the identity, resemblance, and representative character of the coral species of the consecutive reefs lead to the inference of a continuity of a reef-fauna somewhere or other during the whole Oolitic period. The absence of deep seas close to continental tracts must be admitted; but the presence of such geographical elements as now obtain in the Indo-Pacific may be fairly asserted.

The extent of the coral-sea appears to have reached its maximum during the Great Oolite; and then the conditions which had prevailed so long, and which had furthered the continuance of the successive reefs, began to alter.

The indications of reefs diminish very decidedly in the Oxford group and its continental equivalents in France, Switzerland, Swabia, and Franconia. Moreover our so-called Coral-rag is very poor in species, although it was clearly deposited in a reef-area. Whilst the reefs on our area were in existence there do not appear to have been any in Northern and Western France, Eastern Switzerland, or to the east. There *Trigonia* limestones, *Cidaris* limestones, *Ammonites* limestones and shales appear to have prevailed. But in Western Switzerland there were successive reefs which commenced before our horizon of

* Wright, *op. cit.*

Cidaris florigemma and the coral-reef were distinguishable. The lower part of the Kimmeridge group contains the relics of a reef in the Rochelle district; but there are only deep-sea Mollusca and *Ammonites* to indicate the marine conditions in England, Central Europe, and the rest of France.

Coral-life had departed from our area, and did not return during the deposition of the Kimmeridge Clays; but a small reef-area, where one species of Coral alone is found, existed during the Portland Oolite. But elsewhere in Western Europe* there was always a reef in some locality or other during the very varying conditions of sea-depth of the Kimmeridge age. In the middle part of the Kimmeridge, on the horizon of *Pteroceras Oceani* and *Ammonites mutabilis*, the coral-area was around Natheim and in Franconia; and in the upper part, the coral-sea was still absent in the west, but there were reefs in Franconia which were of the same general age as the Solenhofen slates. There was a deep sea on our area and evidences of land close by; and the same evidences presented themselves in Western Switzerland. The variations in the depth of the sea-bottom must have been very considerable to have destroyed reefs in one area and to have enabled them to exist in another and to be again succeeded by deep-sea and even terrestrial deposits. The species of these wandering and successive reefs are identical or closely allied.

The last glimmer of the Oolitic coral-life in Western Europe was in the Portland Oolite; and the feeble reef of our area was part of a system which reached to Western Switzerland. But the progress of a great and general elevation of the Oolitic sea-bottoms had been gradually overcoming the temporary subsidences of portions of the area, and finally the land-surface of the Wealden arose over large spaces.

Neocomian Strata.

Until lately, the strata of this part of the Cretaceous Formation in England were supposed to have been almost uncoralliferous, only one species having been described. Mr. C. J. Meyer, however, has studied the Bargate stone, and has furnished me with some specimens which give a definite character to the Neocomian sea of the south of England.† The species are such as would, in the existing seas, denote a moderately deep sea and littoral tracts remote from, but still under the influence of, a reef-area. They are not true deep-sea species. Now the reefs of the Neocomian period closest to our area were about St. Dizier (Haute Marne) and in the Department of the Yonne. There were others in the Hautes Alpes; and the German reefs were around Schoppenstedt, Elligser, and Berklinger. The reefs of the Yonne were as abundant in species as those of the Oolites. Although the same genera were present, the species were not identical; they were representative and grouped in the same manner. There must have been some great physical break between the formation of the Neocomian reefs and the destruction of those that pre-

* Waagen, Quart. Journ. Geol. Soc. vol. xxi. part 2, p. 14.
† Pal. Soc.: P. M. Duncan's 'Brit. Foss. Corals,' 1869.

ceded them; and at the same time there must have been a persistence of reef conditions within the limit of the migration of corals during the Kimmeridge and Portland period, and without the area of Western Europe.

If the Neocomian is regarded in a general sense as the marine equivalent of the Wealden, some insight may be obtained concerning the great elevation of parts of the Jurassic sea-bed which occurred before the commencement of the Cretaceous era. The opinion of Elie de Beaumont, that a great upheaval, which he has named the system of the Côte d'Or, took place before the sediments of the lower Cretaceous seas began to form, is worthy of careful consideration. It would appear that long ranges of the Jura and Cevennes, and granitic rocks covered with Oolitic outliers were tilted and elevated before the sediments of the Neocomian period were deposited uncomformably and horizontally in relation to them. If this was so, the varying bathymetrical conditions already noticed as characterizing the sea-bottoms of the Upper Oolites culminated in an upheaval, which produced land in one portion of the area of Western Europe, and determined the presence of the physical conditions favourable for coral-life in another.

The Gault.

When the species forming the Coral-fauna of the Gault are compared with recent forms, there is no difficulty in asserting that they were dwellers in deep water, and not within the range of reefs. Some of them, probably, were littoral kinds. All are specifically distinct from the Neocomian corals, and present a different facies. Nothing is known concerning the reefs of this period; and the few species of the generally very uncoralliferous strata of the Continent are deep-sea forms.

Upper Green Sand.—Upper and Lower White Chalk Strata.

The gradual subsidence of great spaces of the sea-bottom, which probably determined the peculiar fauna of the Gault, and the absence of reefs, appears to have continued in some localities during the deposition of the Upper Green Sand strata; whilst it was preceded in others by an elevation of the old sediments. The coral fauna of the English Upper Green Sand is representative of that of the Gault, but the species differ. There were littoral and deep-sea forms in both; and in the south-west of England, at Haldon, there was a reef. On the Continent, the strata of the period indicate every known variety of deposit, and very varying bathymetrical conditions. Reefs succeeded various deposits, and occupied different geological horizons; and all had a definite relation to each other, both in the identity of the species and the accompanying mollusca.

It is impossible to separate the English Upper Green Sand and Lower White Chalk from the formations at Gosau, in Austria, and the reefs in the south of France, where Hippurites are mixed up, like gigantic Chamas, with masses of compound corals to form reefs. Few generalizations have been more useful than those of Messrs. R.

Godwin-Austen and Sharp concerning the relations of the English Upper Green Sand and Lower White Chalk,—that, in fact, the first deposits were covered by the last during a period of subsidence, and that oceanic conditions prevailed over the littoral. Since the corals of the Gosau district have been compared with those of Les Bains de Rennes, the Montagne des Cornes, Martigny, and Figuières, it has become evident that large tracts of the French, Spanish, and Austrian areas were occupied by coral reefs, which were formed and destroyed, after producing enormous sediments, whilst the oceanic conditions of the British, Belgian, and North German areas prevailed. There were also deep-sea formations going on far away to the east whilst the reefs of Gosau were flourishing. Yet the oceanic conditions outlasted those of the reefs, and the sediments of the deep sea evidently covered up those of the reef-areas as the great subsidence of the period progressed. There were then two coral faunas living at once on the Western European area. The reef-species were very numerous, and were closely allied not only to the Neocomian forms, but also to those of the Oolites. The alliance is greater with the Neocomian fauna than with the Oolitic; but there is a remarkable similarity of "facies" between the three groups of forms, which reminds the naturalist of the peculiarities of the existing corals of the Pacific. This arises from there being many genera which were represented in the Lower Cretaceous reefs, and which exist in those of the Pacific.

The fauna of the Upper and Lower White Chalk, on the other hand, is essentially represented by that of the existing deep-sea coral fauna of the North Sea and the Atlantic, on the west coast of Ireland, down to the Straits of Gibraltar. The *Caryophylliæ* of the Chalk are closely allied to the existing species, and the branching *Synhelia* is represented by *Lophohelia*. The homotaxis of the Cretaceous deposits and those now forming is very extraordinary.

The uppermost deposits of the White Chalk in Denmark and Holland contain a few traces of shallow-water and reef corals; and the end of the Cretaceous coral-period resembled that of the Oolitic.

Nummulitic Period.

The fossil corals of the London Clay, Bracklesham, and Barton beds, indicate varying bathymetrical conditions: some of the species were littoral, and others were wanderers from a reef-area. The corresponding deposits on the other side of the Channel contain many of the British species, and were formed under the same external conditions. The reefs of the period covered vast areas. The typical reefs were in Styria, about Oberburg; others were in the Vicentin, the Tyrol, Switzerland, the Maritime Alps, Corbières, Nice, the Pyrenees, and Biarritz. The reefs were continued into the Crimea, Egypt, Syria, and Arabia; and the Hala Mountains, in Sindh, contain as great an aggregation of reef-making genera as modern reefs. The Oberburg fauna was highly developed, and contained all the varied styles of mæandriform, branching, and massive corals

that now occupy definite positions in the reefs of the Indo-Pacific. Even the great reef-making genera *Millepora*, *Porites*, *Alveopora*, *Madrepora*, and *Heliastræa* are represented in the Eocene reefs by numerous species. The number of species in the old reefs quite equals that in the existing ones. The stragglers from the reefs which formed a part of the British Eocene coral fauna are of the genera *Stereopsammia*, *Dendracis*, *Porites*, *Litharea*, and *Axopora*. These forms, associated as they are with the *Dendrophylliæ*, would not be out of place in such an area as the sea-bottom to the south of China, or the Gulf of Mexico.

Great variations of depth occurred in these coral areas; for deep sediments containing Nummulites overlie the reefs either directly or by inference, and there is a profound flysch superior to the Oberburg, but not in the same district. The Nummulites appear to have favoured the reef-areas.

Oligocene.

The coralliferous deposit at Brockenhurst, in Hampshire, rests upon a freshwater formation which is the equivalent of the freshwater beds of the Lower Headon series. The species of corals are of genera which now characterize reefs, and the most prominent are *Madrepora* and *Solenastræa*. The mollusca associated with the corals are identical, for the most part, with those which are found in the Oligocene strata of Tongres, Magdeburg, and Latdorf; and they belong to a well-characterized horizon between the Nummulitic and the Faluns. The corals of the three localities just mentioned are deep-sea and littoral forms more or less under the influence of a reef; but the true reefs were in Hampshire and in the Castel-Gomberto district, where they can still be recognized in great masses.

These reefs contain no less than 50 genera of corals; and there are many species there which are found in the Nummulitic and Miocene reefs associated with characteristic forms. The Oligocene reefs differed, in species, about as much from those which immediately preceded and followed them as the existing West-Indian reefs do from those of the Pacific and South Sea.

The relation of the Oligocene reefs to certain great bathymetrical changes is obvious; and the Brockenhurst reef was located upon an area which had been upheaved after the Barton deposits had been completed and again slightly depressed. The deep water in the German area covered extensive Brown-coal strata.

The reef-corals began to diminish in the number of their species after this time; and the Miocene reefs formed in south-western France, northern Italy, Austria, Hungary, Spain, and Malta, do not present so varied an assemblage as those of the two preceding formations. The oscillations of the south-western area of Europe were very great between the Oligocene and the Miocene; and during this age reefs and barriers were associated with considerable land-surfaces, and with very variable conditions of sea-bottom. The partial upheaval of the Alps (which had been a reef-supporting series of hills for two periods) into mountain-ridges, and the general volcanic

phenomena of the Rhine provinces and central France, depended upon secular operations which were also elevating the whole Continent and producing rivers and sediments, and they rendered coral-life at first difficult and then impossible. The deep sea of the period was in the North Atlantic, and the reefs went round the globe like a belt. The Maltese reefs felt the warm currents of the area now occupied by the Sahara; and the reefs of Asia Minor and of the west of Arabia on the east, with the coral-tracts of the Isthmus of Panama on the west, opened the main oceans of the globe in one continuous track of island, atoll, and lagoon. The duration of the Mid-tertiary age, or of the period which commenced after the destruction of the Castel-Gomberto reefs, and ended with the grandest upheavals of the highest mountain masses in the world and the destruction of the Arctic barriers of Forbes and Austen *, was immense; nevertheless the old and oft-repeated scheme of reef-formation and grouping of genera and species prevailed through it, and left its impress upon the present coral-tracts of the Caribbean and the Indo-Pacific areas.

The Crag.

The littoral and deep-water species of corals found in the Crag are either identical with, or are very closely allied to forms now existing in the British seas and the Atlantic off the western coast of Europe. The Pliocene deposits of the sub-Appenines and Sicily and those of Malaga contain species closely resembling, and some identical with, those of the deep water of the Mediterranean, and some found in the greatest depths of the seas to the west of Europe. There were no reefs on the European area, and the Belgian Crag tells the same story as ours. The reefs were where they now are.

There was probably very little difference between the general characteristics of the seas of North-west Europe during the Crag-time and the present.

XI. Conclusions.

The oldest Mesozoic reefs appear to have been formed upon the same plan as those which succeeded them through the consecutive geological ages; and all had the same general grouping of families, genera, and shapes which prevails in every modern reef. The scheme, which was feebly represented in the oldest reefs, became more fully developed in the Oolitic period, and was as perfect during the Nummulitic age as it is now. The faunas of the consecutive reefs rarely had species in common, but the genera were most constant and persistent. Certain coral-shapes and methods of growth and of reproduction prevailed during the whole of the periods; and there is a fair inference to be drawn that the external physical conditions which now are absolutely necessary for the formation and persistence of great aggregations of corals were present during the Mesozoic and Cainozoic periods.

These physical conditions have a geographical importance; and

* Forbes and Austen 'Phys. Geog. Europ. Seas.'

the same disposition of islands, deep and shallow seas, with remote continental spaces and rivers, which now prevails in the coral-areas, must be suggested to have existed in the reef-bearing seas of the past. The simplicity of the physical conditions, and their continuance on some one area during all ages, offer an explanation why the species and genera of the reefs and deep seas are respectively so representative and so evidently formed upon one definite plan.

There are relations, which can only be hinted at in this communication, between the floras and the reptilian and mammalian faunas of present coral-areas and those of the past. But the persistence of coral-seas, with intervals of deep seas and altered physical conditions, during the Liassic, Oolitic, and Cretaceous ages, for instance, may explain the singularly defective mammalian fauna, and the characteristic nature of the reptiles of the strata that contain a flora so representative of the Equatorial coral-seas.

The first land-surface of the Trias in western Europe became, in some localities, a sea, and a coral-sea; and before the end of the period a great upheaval took place, and a second coral-sea—the reult of subsidence—was formed. A deep sea in the north and reefs in the east of the area followed, after the prolongation of a stationary condition of some Triassic surfaces, and after an upheaval of others. The reefs of the Lower Lias, so evidently representative of those of St. Cassian, were partly contemporaneous with, and partly successive to, the deep seas of the Rhætic, which may be regarded as an intercalated series. Europe was a coral-reef area during the Lower Lias; but great bathymetrical alterations then occurred, and consecutive but very closely allied coral faunas appeared on it. The Upper Lias witnessed the culmination of those alterations which were destructive to the reef-faunas. The Oolitic coral-seas which followed had a coral fauna closely allied to, and representative of, the Lower Liassic, although a great break had occurred in the European area between the periods. All the peculiar physical conditions returned, and persisted longer on the Continent than in the space now occupied by England. Coral formation after coral formation appeared and gave way to the overwhelming results of altered sea-depth; but throughout the period the character of the fauna altered but little. The Neocomian period had a reef-bearing sea in the Central-European space, and deep and shallow waters on our area. The physical break which occurred between the Coral rag and the Neocomian, witnessed the destruction of coral-life over large areas; but the two faunas were nevertheless closely allied and representative.

The Green Sands and White Chalk of the north-west of Europe were deposited in increasingly deep seas, whilst the reefs were in full force in Central Europe. The affinities of the reef-builders of this age were not with the corals of the Gault, but with those of the Neocomian; and the deep-sea forms were somewhat representative of those of the very uncoralliferous deep seas of the Gault.

The great break between the Cretaceous and Nummulitic strata in Europe is well appreciated by all geologists; and the opinion of Forbes and Austen, that the Tertiary seas of Europe washed a great

group of islands, receives additional force from the study of the successive reef-areas of the Nummulitic, Oligocene, and Miocene periods. The first of these contained a coral fauna which was as representative of that of the Cretaceous reefs as this was of the Oolitic; and thus there is another example of the remarkable return of closely allied forms to the same area after great alterations in its physical geography had occurred. The Oligocene and Miocene reefs were the last on the European area; and the present deep-sea coral fauna of the Mediterranean, North Sea, and north-eastern Atlantic is representative of the deep-sea coral fauna of the White Chalk.

The alliances between the consecutive coral faunas which were separated by deposits containing the evidences of conditions most unfavourable to coral-life indicate that there has been an unbroken series of reef-areas within the scope of the emigration of Madreporarian ova ever since the Trias. Sometimes the reef-bearing seas were on the European area; and then it probably resembled, in its geography and natural history, a modern coral-sea. At others the physical conditions which characterize the existing state of things prevailed; and then the coral-tracts were remote, and either deep-sea forms existed or none at all. Doubtless the continental land was very persistent in Northern Europe, and the Arctic sea was shut out until the termination of the Mid-tertiary age. The land probably often encroached upon the coral tracts, and determined their partial or entire destruction.

Its influence may have been like that of the American continent upon the Caribbean Sea. During the Miocene, Trinidad was a vast reef, hung on to the older Parian hills, which were submerged and far away from land, and it was one of a series. But as the South-American coast uprose and the drainage of the new continent was poured out through the valley of the Orinoco, so great a mass of fresh water and muddy sediment contaminated the Trinitatian area, that hardly any corals grew around its old reefs after they they had been upheaved in common with the Miocene deposits of the Caribbean Sea. A short distance to the north, however, the new coral fauna encircles the old.

Discussion.

Prof. Alexander Agassiz accounted for the circumscribed area of many corals in the Atlantic from the young of many coral species attaching themselves within a few hours of their becoming pelagic. He traced to the great equatorial current which must have traversed the Isthmus of Panama and the Sahara in a precretaceous period the distribution of certain forms, which the rising of the Isthmus of Panama eventually checked. He mentioned the formation of a reef at the present time off the coast of Florida, which threw light on the manner in which mudflats were formed, and the sea eventually filled.

Mr. Gwyn Jeffreys objected to the term "deep sea" being applied to a depth of 10 fathoms only, when the tide in some places rose to that extent, and the laminarian zone extended to 15. He

suggested 50 fathoms as a more appropriate measure. He remarked on the great vertical range of some simple corals, such as *Caryophyllia Smithii*, which extends from low-water mark to at least 150 fathoms. In deep-sea water it is frequently attached to various shells, especially *Ditrypa* and *Aporrhaïs*. Another simple coral of our seas, *Desmophyllum* (*Ulocyathus*) *arcticum*, had not been found at a depth of less than 75 fathoms. Compound corals occurred only at considerable depths.

Dr. Duncan drew a distinction between coral-reef areas and those in which different conditions prevailed. His argument had not so much been based on the depth of the sea as on the presence or otherwise of coral-reefs. The term deep sea had been given by Prof. Forbes to depths of 10 fathoms and upwards. For such depths as those explored at the present day no term short of "abyssal" was appropriate.

December 8, 1869.

Charles E. De Rance, Esq., of the Geological Survey of England and Wales; John E. Taylor, Esq., Hon. Secretary, Norwich Geological Society, Bracondale, Norwich; Rev. George Henslow, M.A., F.L.S., St. John's Parsonage, St. John's Wood, N.W.; C. J. A. Meyer, Esq., 8 Church Buildings, Clapham Common, S.W.; J. Harper, Esq., Claremont House, Chaucer Road, Dulwich, S.E.; John Yeats, LL.D., Clayton Place, Peckham, S.E.; J. S. Holden, M.D., Glenarm, co. Antrim; David Robertson, Esq., 4 Regent's Park Terrace, Glasgow; Walter Buller, Esq., F.L.S., Wanganui, New Zealand; and J. H. Collins, Esq., Royal Institution of Cornwall, Truro, were elected Fellows of the Society.

The following communications were read:—

1. *Notes on the* Brachiopoda *hitherto obtained from the* "Pebble-bed" *of* Budleigh-Salterton, *near* Exmouth, *in* Devonshire. By Thomas Davidson, Esq., F.R.S., F.G.S., &c.*

(Plates IV.–VI.)

Introduction.

On the 16th of December, 1863, Messrs. W. Vicary and J. W. Salter made an important communication to the Geological Society on the "pebble-bed" at Budleigh-Salterton, wherein some thirty-six different fossils were described and illustrated; of these, ten or twelve were Brachiopoda.

Since that period Messrs. Vicary, Valpy, Edgell, Box, Winwood,

* This paper was read at the Exeter meeting of the British Association, in August 1869, but has subsequently undergone considerable revision.

and others have been zealously at work collecting additional information, and every specimen that might assist in determining the age of the rock from which these drifted pebbles were derived has been carefully preserved*.

The Brachiopoda were transmitted to me at various times for examination. I have studied and compared them, so far as this was compatible with the preservation of the specimens. These fossils occur in the shape of internal casts and external impressions only; but by the aid of gutta-percha it was often possible to reproduce the external as well as the internal surface of both valves, and thus describe and figure the entire shell in as complete a manner as if taken from the sea. There are, however, a number of species which have occurred but once, or very rarely, and in so incomplete a state of preservation that it has frequently been impossible to arrive at a decided or satisfactory specific identification; and in such a difficult problem as the age of these pebbles at Budleigh Salterton, one cannot be too cautious in the identification of the fossils which they contain.

After the careful examination of several hundred specimens, I have been able to recognize from thirty-seven to forty species of Brachiopoda, besides many fossils referable to other classes. Of some of the former, descriptions have already been published in my Monograph of Silurian Brachiopoda.

The rock or pebbles containing these fossils, as described by Mr. Vicary, "is generally a Sandstone, but sometimes so compact as to assume a quartzite character." The colour of the rock is very variable, being either white, grey, yellow, or more or less strongly tinted with red. The size of the boulders varies considerably; they have been completely rounded and polished by the action of the waves over a rough bottom; and a comparatively small number seem to contain fossils. The pebble-bed, on the coast, in its thickest part, is not much more than 100 feet thick; it caps a ridge of hills running inland to the north full twelve miles, extending down both sides of these hills, in some places, to the extent of three or four miles. Most of the fossils are found near the coast; and I am informed that some few have been likewise met with in the Straightway pits, where pebbles are broken for the roads; but none were ever found in that locality by Mr. Vicary. The pebbles are largely distributed with flints in the gravel-beds of the neighbourhood†.

From the appearance of the pebbles and their accumulation in the cliff at Budleigh-Salterton and in other spots, irrespectively of their fossil contents, it would be natural to arrive at the conclusion that they all belong to a rock of the same age, transported thither at a period subsequent to its formation; and this view is, rightly or wrongly, entertained by several geologists. It has been likewise asked:—How can fragments of rock, varying in age, be accumulated in the same pebble-bed? They could not have come from different localities; and if

* The discovery of by far the largest number of species is due to Mr. Vicary.

† See also a paper, by Mr. Pengelly, "On the Denudation of Rocks in Devonshire."

from the same, has there ever been a case observed where rocks containing Devonian fossils overlie Silurian ones with Silurian fossils, the matrix being the same in both cases*? The question is difficult to answer; but when we examine the contents of these "pebbles" (or "popples," as they are locally designated), it is not easy to suppose them of the same age, if our identification of the fossils is correct, because, so far as I know, in no locality hitherto investigated has such an assemblage been exhibited; but I would again remark that were we not positively assured by Messrs. Rouault, Salter, and De Verneuil that three or four of the Brachiopoda are in reality Lower-Silurian fossils, it would not be very difficult, I think, to refer most of them, if not all, to a single period. None of the rocks known in England have, however, presented a similar fauna; nor have the red sandstone and quartzite beds of May and Fengrolles in Normandy, any more than those described by M. Rouault in Brittany, furnished more than a very small proportion of the species found in the Budleigh pebbles. Mr. Vicary seems, however, to believe that they may have been derived from a nearer source, and that they once formed a beach in the New Red Sandstone sea, similar to that of the Chesil bank near Portland; but we have no evidence of this that I can collect in the Channel; and even if such a bed did exist, it would not clear away the difficulty connected with the presence of fossils of two distinct periods (?). It has been suggested that a great similarity exists between the Budleigh fossils and those described by Messrs. Ribeiro and Sharpe from the Serra de Bussaco, in Portugal†; but I could not identify with certainty a single species of Brachiopoda as common to the Portuguese locality and that of Budleigh Salterton. It is true that those authors state that the lowest division of the Silurian system in Portugal is composed of quartzites, micaceous sandstones, &c.; but I can hardly suppose that any of the Budleigh boulders were drifted from that locality. A mystery still hangs over the derivation of these boulders, nor can I account for the supposed and extraordinary mixture of Silurian and Devonian forms in the same locality; but I must place a reserve on the above statement, and qualify my meaning—namely, that although in this "remanié" deposit there appears to exist an assemblage of species peculiar to two distinct epochs, this *mélange* does not seem to occur in the same pebble; on the contrary, every individual boulder contains specimens referable either to the one or to the other epoch; so that no *mélange* has been hitherto detected in the same pebble, or existed in the parent rock. It is to my mind quite certain (and I am supported in this opinion by M. de Verneuil) that those boulders which contain *Spirifera Verneuilii*, *Rhynchonella inaurita*, *Streptorhynchus crenistria*, *Productus Vicaryi*, *Chonetes*, &c. are of Devonian age; consequently all other forms that occur in the same mass of rock along with these must necessarily belong to the same period.

* We all know that conglomerates containing fragments of rock of different ages have been met with in several places. It is the matrix being the same that causes the difficulty.

† Quart. Journ. Geol. Soc. vol. xx. p. 135, 1853.

There cannot be the smallest uncertainty as to the identification of the *Spirifera Verneuilii* and *Productus* above named, although Mr. Salter had, in 1863, proposed for the first the designation of *Spirifer antiquissimus*, and for the second that of *Leptæna Vicaryi*; but I know that my distinguished friend was willing to admit having been misled from supposing the pebbles in question to be of Lower-Silurian age, wherein no *Productus* has ever been detected. Mr. Salter had, however, in 1863, hinted at the possibility of some Devonian species or pebbles having been introduced into the Budleigh deposit, which he alludes to in his description of the so-called *Spirifer antiquissimus*, as well as of the *Rhynchonella* (*R. inaurita*, Sandb.) which occurs abundantly along with *Spirifera Verneuilii* in so many of the boulders. Unless, therefore, we are disposed to admit that these Devonian species did live also in the Lower-Silurian period (which we have no direct evidence to support), we are unavoidably led to conclude that, with very few exceptions, the Brachiopoda found in the Budleigh pebbles are of Devonian age, and that the few Silurian ones are the exception, not the rule, in the accumulation of boulders in that remarkable locality.

If we can with certainty determine the age of the last-named species, we shall find considerably more difficulty in dealing with, or positively fixing the age of those few species that have been stated and supposed to be Silurian. In the memoir by Messrs. Vicary and Salter, already quoted, which was published in the 20th volume of the 'Quarterly Journal of the Geological Society,' Mr. Salter describes and figures nine species of Brachiopoda (the additional three being synonyms of the others), and refers them all, more or less positively, to the Lower-Silurian period; but, as we have already shown, three or four only are Silurian, while the remaining species are of indubitable Devonian age.

It is now of much importance to examine with great attention those species said to be Silurian; and I admit having experienced the utmost difficulty and uncertainty during the progress of this investigation, and even now entertain misgivings upon the subject.

Lingula Lesueuri was found by M. Rouault at Guichen, in Brittany, in a white or bluish sandstone, or quartzite, which he refers to the Lower Silurian series, as forming part of his "Etage du Grès Armoricain," referred by Mr. Salter to the age of the Arenig or Skiddaw slates (the lower Llandeilo of Murchison). When recently in Paris, M. de Verneuil assured me that he and M. Triger had discovered the same shell in the "Grès à Bilobites" of St. Léonard, Sarthe—the rock being situated under the slates of Angers (Lower Llandeilo flags), and *Lingula Hawkei* (Rouault) and *L. Rouaulti* being of a similar age. We have likewise, as one of the most abundant fossils of these supposed Silurian pebbles, a small *Orthis*, which Mr. Salter identified with the *O. redux* of Barrande. I will not positively assert that Mr. Salter was mistaken; but a lengthened comparison of many of the Budleigh specimens with the two figures given by Barrande has led me to think that they may be specifically distinct, and that the Budleigh shell is, perhaps, of Devonian age. It is true, again, that a small *Orthis*, somewhat resembling the

Budleigh species, occurs abundantly in the reddish sandstone, or quartzite, of May, near Caen, in Normandy, a rock referred by most geologists to the Caradoc, and asserted by Mr. Salter to lie above the Armorican Sandstone with *Lingula Lesueuri*—a formation seemingly part of the great slaty series of Angers, therefore far underlying the May sandstone; he further adds, "In brief, then, the mass of the Budleigh-Salterton fossils are Norman types of the May Sandstone, and some belong to the 'Grès Armoricain;' several of the species have been already named in France, and some of the more conspicuous shells, though apparently undescribed, are characteristic of the rocks on both sides of the Channel." I must nevertheless observe that very few of the forty species of Brachiopoda found at Budleigh-Salterton have hitherto been obtained from the Middle and Lower Silurian rocks of Normandy and Britain*. Mr. Vicary has never yet found *Orthis redux*?, var. *budleighensis*, associated with *Lingula Lesueuri*; indeed very rarely do we find this last-named shell in company with other Brachiopoda in the same pebble. It is, moreover, not easy to be certain about the correct identification of some of the incomplete internal casts and impressions of the Budleigh species of *Orthis* and *Strophomena*, which may be, most probably, Devonian forms; so much do the species of those genera in the two periods sometimes resemble each other, notwithstanding their specific distinctness.

Now, as it is quite certain that all the species found in the same pebble with one or more of those forms believed to be correctly determined must be of the same age, we shall find, as far as our present imperfect knowledge will carry us, that only three or four of the species of Brachiopoda have been, with some degree of certainty, referred to the Lower-Silurian period; while eight or nine, supposed to be Silurian, and which have occurred in the same stones with *Orthis redux*, Barr.?, var. *budleighensis*, must remain for the present of undetermined age, although they possess much more of the Devonian than of the Silurian facies. Twelve or thirteen are unquestionably Devonian shells, while the remaining fourteen, either being new or not having hitherto occurred or been found with any of those already recorded as Silurian or Devonian, cannot yet with certainty be correctly located; but they seem, to my eye, to possess in most cases a very decided Devonian aspect.

It is highly probable that when the species of the other classes also occurring in these pebbles shall have been carefully and critically examined, the true age of the fossils generally will be established, as the whole series must be taken into consideration before we can expect to arrive at any definite conclusion. But all tends to show that the great bulk of the fossiliferous pebbles at Budleigh-

* Mr. Godwin-Austen informs me that he believes these boulders to be of French origin, and that he knows of a pebble-band belonging to the New Red series in Normandy, identical with that at Budleigh—but that if I ask whence do the pebbles come, and where is the parent rock, he must answer that he does not know, but that in Lower Normandy the palæozoic series is not well exposed and has been much denuded.

Salterton are of Devonian age; and I am glad to be able to add that, after having examined my drawings and heard my views, Mr. Salter had, both by word and letter, frankly admitted having been mistaken when he referred all the fossiliferous pebbles at Budleigh to the Lower-Silurian period*.

Silurian Species (according to Rouault and Salter).

1. Lingula Lesueuri (*Rouault*). Not very rare.
2. —— Rouaulti (*Salter*). Not very rare.
3. —— Hawkei (*Rouault*). Not very rare.

Species of which the age is not certain; all occur in the same rock.

4. Orthis redux (*Barr.*?), var. budleighensis (*Dav.*). Very abundant.
5. —— Valpyana (*Dav.*). Not very rare.
6. —— Vicaryi (*Dav.*). Not common.
7. —— Berthoisi, *Rouault*?, var. erratica (*Dav.*). Not very rare.
8. Spirifera octoplicata (*Sow.*), or S. elevata (*Dalm.*)? Not common.
9. Rhynchonella? ovalis, *Dav.* Not common.
10. Terebratula?. sp.? Very rare.
11. Strophomena, sp.? Rare.

Devonian Species.

12. Spirifera Verneuilii (*Murch.*). Very common.
13. —— macroptera, var. microptera (*Goldf.*). Rare.
14. Athyris budleighensis (*Dav.*). Rare.
15. Atrypa, sp. (perhaps *reticularis*). Rare.
16. Rhynchonella inaurita (*Sandb.*). Very abundant.
17. —— elliptica (*Schnurr*?). Rare.
18. —— Vicaryi, *Dav.* Not common.
19. ——, sp.? Rare.
20. ——, sp.? Rare.
21. Streptorhynchus crenistria (*Phil.*). Rare.
22. Productus Vicaryi (*Salter*). Common.
23. Chonetes, sp. Rare.

Species presenting a Devonian facies, but whose positive age cannot yet be correctly decided.

24. Lingula? Salteri (*Dav.*). Not common.
25. Discina Vicaryi (*Dav.*). Not common.
26. —— incerta (*Dav.*). Rare.
27. —— ? Edgelli (*Dav.*). Rare.
28. Crania transversa (*Dav.*). Rare.

---

* In a very interesting memoir "On the Lower Silurian formations in the Department of the Manche in France" (Mémoires de la Soc. Imp. des Sciences de Cherbourg, vol. ix. 1863), M. Bonissent notices beds of Red Sandstone, or quartzite, which in many localities, carefully described by him, contain *Orthis redux*, *O. Berthoisi*, *O. Davidsi*, *O. Damjoui*, and a large undescribed species of the same genus associated with *Calymene Tristani*, *Dalmanites socialis*, &c. These sandstones are considered by him to be equivalents of the Grès de May, near Caen, in Normandy. The *O. redux* occurs in the Department of the Manche, and not far from Cherbourg, both in quartzites and in schists which the author refers to the "faune seconde" of Barrande, or stage of the schists of Angers. If, consequently, our little Budleigh species agrees specifically with the form so named by M. Bonissent, the eight species occurring along with it in the same rock or pebble at Budleigh Salterton, will have to be considered Silurian. M. Bonissent mentions likewise the presence of *Lingulæ* resembling *L. Lesueuri* in some of the sandstone beds of the same Department.

29. Athyris? incerta (*Dav.*). Rare.
30. —— erratica (*Dav.*). Rare.
31. Nucleospira Vicaryi (*Dav.*). Not common.
32. Orthis pulvinata (*Salter*). Not common.
33. Strophomena Rouaulti (*Dav.*). Rare.
34. —— Etheridgii (*Dav.*). Rare.
35. —— Edgelliana (*Dav.*). Rare.
36. —— Vicaryi (*Dav.*). Rare.
37. —— budleighensis (*Dav.*). Rare.

And two or three more species, not sufficiently complete for specific identification.

Notes on and Descriptions of the Species.

1. Lingula Lesueuri (Rouault). Pl. IV. fig. 1.

Bull. Soc. Géol. de France, vol. vii. 2nd ser. p. 727, 1850; Salter, Quart. Journ. Geol. Soc. vol. xx. p. 292, pl. xvii. fig. 1; Dav. Sil. Mon. p. 42, pl. i. figs. 1–11.

This curious species has been correctly described and illustrated by Mr. Salter and myself. I, however, much regret that M. Rouault did not figure his French type. It varies considerably in its comparative length, so that the sides, instead of being always subparallel, sometimes diverge at once from the beak to the frontal margin; and it might, under that aspect, be readily mistaken for a distinct species. *L. Lesueuri* was found *in situ* by M. Rouault in the Lower Silurian (Lower Llandeilo), at Guichen, in Brittany, and by MM. E. de Verneuil and Triger at St. Léonard, in the Department of the Sarthe. It is not very rare at Budleigh-Salterton, and was once found by Mr. Vicary associated with *Rhynch. Vicaryi*. The Rev. P. B. Brodie mentions having picked it up, as well as *Orthis redux*, var. *Budleighensis* (but separately), in quartzite or sandstone pebbles similar to those discovered by Mr. Vicary, in the drift at Rowington, in Warwickshire. The shell which approaches most to *L. Lesueuri* is the *L. Bechei* from the Upper Llandovery of Marloes Bay.

2. Lingula Rouaulti (Salter). Pl. IV. fig. 2.

Quart. Journ. Geol. Soc. vol. xx. p. 293, pl. xvii. figs. 4 & 5; Dav. Sil. Mon. p. 40, pl. i. figs. 14–20.

This is a very remarkable species, and has been described and illustrated by Mr. Salter and myself. I have seen French examples in the collection of M. E. de Verneuil which agree with ours, but the shell seems to have attained somewhat larger proportions in the "Armorican Grit" of Brittany. Certain specimens bear much resemblance to *Lingula crumena*, Phillips, with which it might sometimes be confounded. *L. Rouaulti* is a Lower-Silurian species and not very rare at Budleigh-Salterton; but no other Brachiopod has hitherto been found associated with it in the same pebble.

3. Lingula Hawkei, Rouault. Pl. IV. fig. 3.

Bull. Soc. Géol. de France, 2nd ser. vol. vii. p. 728, 1850; Salter, Quart. Journ. Geol. Soc. vol. xx. p. 293, pl. xvii. figs. 2 & 3; Dav. Sil. Mon. p. 41, pl. i. figs. 21–26.

Lingula Brimonti, Rouault? (according to Salter), Quart. Journ. Geol. Soc. vol. xx. p. 293, pl. xvii. fig. 6.

I believe this shell to have been correctly identified, although no figure was given by the French palæontologist. Some French examples in the possession of M. de Verneuil, however, are much larger and more transverse than any hitherto collected at Budleigh. I am also of opinion that the shell doubtfully identified by Mr. Salter as *L. Brimonti* (Rouault) is no more than a malformation of *L. Hawkei*. It is, according to M. Rouault, a Lower-Silurian species.

4. Lingula? Salteri, Dav. Pl. IV. fig. 5.
Sil. Mon. p. 53, pl. i. figs. 27–29, 1866.

I must here repeat what I said when describing this curious species, namely, that whether it belongs to *Lingula* or *Obolus*, or to some other genus is a question which the material at my command will not enable me to determine; for none of the specimens showed any portion of their interior. It much resembles *Lingula? exilis*, Hall (13th Annual Report of the Regents on the state of Cabinet, p. 76, New York, 1860), a shell occurring in the Hamilton group and Marcellus shale of Bridgewater, New York. Prof. Hall's specimens measured about an inch in length, while an example of *L. Salteri* found by Mr. Vicary had attained 2 inches; it may therefore remain a question whether the American and British specimens do or do not belong to a single species.

Although figured and described in my Silurian Monograph, I cannot say whether it is a Silurian or a Devonian species, as no other known shell has been found with it in the same pebble. I should feel inclined to suppose it Devonian, from its strong resemblance to *L. exilis*.

Besides the four species of *Lingula* above recorded, one (Pl. IV. fig. 4) or two specimens, which might perhaps be referable to another type, have been picked up by Mr. Vicary; and of one of these a drawing will be found in pl. i. fig. 31 of my Silurian Monograph.

5. Discina? Vicaryi, Dav. Pl. IV. fig. 6.
Sil. Mon. p. 67, pl. vii. fig. 13, 1866.

Three or four examples of this *Discina* (?) have been obtained by Mr. Vicary; but, as I have never seen the attached valve, I cannot say positively that it belongs to the genus to which it is provisionally referred, nor can I locate it in either the Silurian or Devonian series with any degree of certainty, because no other known species has been found with it in the same pebble.

6. Discina incerta, n. sp.? Pl. IV. fig. 7.

Shell nearly orbicular; apex one-third of the diameter from the margin; upper valve moderately convex. Length $3\frac{1}{2}$, breadth 3, height 1 line.

This shell is apparently rare; and it is not possible to identify it

specifically with any of the described species, as its external surface is not known.

7. Discina? Edgelli, n. sp. Pl. IV. fig. 8.

I am uncertain as to the genus to which this shell should be referred; in external shape it looks like an *Obolus*, being almost circular, much depressed, and smooth. Length 8, breadth 9 lines. As it was found alone, it is impossible to determine to what formation it should be referred. Two specimens were obtained by Mr. Vicary.

8. Crania transversa, n. sp. Pl. IV. figs. 9 & 10.

Transversely oblong-oval, widest anteriorly; upper valve moderately convex, vertex about one-third of the length of the shell from the posterior margin; surface smooth or marked by concentric lines of growth. Length 6, width 7 lines. Of this shell Mr. Vicary has found two examples. Exteriorly it resembles more than one Devonian as well as Carboniferous species. The interior not having been found, it cannot be critically described; but for the sake of reference I have applied to it the provisional name of *transversa*. It is in all probability a Devonian shell.

9. Terebratula?, sp. Pl. IV. fig. 11.

Of this shell a single valve has been found by Mr. Vicary in a pebble containing impressions of an *Orthis Vicaryi*. It bears some resemblance to *T. inæqualis*, F. A. Roemer (Beitr. zur Kenntniss des nordwestlichen Harzgebirge, pl. iii. fig. 3), a form belonging to the Silurian Spirifer-sandstone; but it would not be safe to identify our English valve with any of the described species of that genus, nor am I perfectly certain that it is referable to the genus *Terebratula*. It is longitudinally oval, broadest and rounded anteriorly, more converging posteriorly, convex, and smooth. Length 8, width 4 lines.

10. Spirifera Verneuilii, Murch. Pl. IV. figs. 19 & 20.

Bull. Soc. Géol. de France, vol. xi. p. 252, pl. xi. fig. 3 (6th April, 1840)=*S. Archiaci* (Murch.); also Dav. Dev. Mon. p. 23, pl. v. figs. 1–12, pl. vi. fig. 15=*S. disjuncta*, Sow.=*S. antiquissimus* and *S. Davidis*, Salter, Quart. Journ. Geol. Soc. vol. xx. pp. 295, 296, pl. xvii. figs. 10–13.

This is one of the commonest fossils found in the Budleigh pebbles, and is identical in shape with those Upper-Devonian specimens which occur so abundantly at Ferques, near Boulogne-sur-mer, and also in Devonshire, Belgium, China, &c. It is found in company with *S. macroptera*, var. *multicostata*, *Rhynchonella inaurita*, *Productus Vicaryi*, &c. It is also the shell to which Mr. Salter applied the names of *Spirifer antiquissimus* and *S. Davidis*.

In the description of this *Spirifera*, Mr. Salter seems very uncertain whether it should be considered a Silurian or a Devonian fossil; for he writes, "To all appearance this is a *Spirifer*, and I am compelled, from the structure of its teeth [dental plates, he should say] to de-

scribe it as such. But we have a British species of *Orthis* (*O. spiriferoides*), in the Caradoc Sandstone, which exactly resembles it in outline and convexity. Otherwise I might believe, with my friend M. de Verneuil, that it was a Devonian fossil introduced into these beds. It would seem that there is at least one allied species of *Spirifer* in the French Silurian deposits, *S. Davidis*, Rouault." The Budleigh species, however, is quite distinct from *Orthis* ? *spiriferoides*.

11. Spirifera macroptera, Goldf. ?, var. *microptera*. Pl. IV. figs. 21 & 22.

Shell semicircular, much wider than long, valves convex, hinge-line as long as the width of the shell, cardinal angles acute, with mucronate wings; fold smooth, with a slight depression or flatness in the middle; lateral portion of valve ornamented with about twelve ribs, or twenty-four on each valve. Length 6, breadth 15 lines.

This shell is not abundant; it has been found once or twice in the same pebble with *S. Verneuilii* and *Rhynchonella inaurita*. I am not, however, quite certain with reference to the correctness of my identification of it with Goldfuss's *S. macroptera*; but I know of no nearer form with which it can be at present compared.

12. Spirifera octoplicata, Sow. ? Pl. IV. fig. 23.

In external shape the Budleigh specimens closely resemble the Devonian and Carboniferous species; but some examples are also not unlike *S. elevata* of Dalman. It occurs sparingly in the same rock with a *Strophomena*, *Orthis Vicaryi*, and two or three other forms. It differs also in the respective number of lateral ribs.

I could make out with certainty no more than the three species above recorded; but one or two imperfect internal casts have been found which may perhaps belong to another *Spirifera*.

13. Nucleospira Vicaryi, n. sp. Pl. IV. figs. 15–18.

Shell transversely suborbicular; valves moderately convex, most so near the beaks. In the dorsal valve the mesial fold is wide and of small elevation, rising towards the front; beak of ventral valve small and incurved; surface smooth, marked by a few lines of growth. In the interior of the dorsal valve the bifid cardinal process projects considerably, while under it rises a narrow ridge which extends to the front and thus divides the shell into two portions. The muscular impressions lie on either side of the posterior half of this ridge. In the interior of the ventral valve a mesial ridge is likewise present, which, as in the dorsal one, divides the shell into two equal parts. On either side are located the muscular impressions. Two examples measured respectively:—

Length 7, breadth 9, depth 2 lines.
" 5 " 6 lines.

This remarkable species seems referable to the genus *Nucleospira*, and approaches, by its size and character, to *N. elegans*, Hall (Pal. N. York, vol. iii. p. 222, pl. xxviii. B, figs. 10 & 15). It varies in

form—some examples being almost circular, while others are transversely oval. *N. Vicaryi* is not rare in certain pebbles, no less than thirty-five specimens, representing different ages, having been found by Mr. Vicary. It bears also some resemblance to *N. ventricosa*, Hall, and is probably of Silurian age, for it has been found associated with impressions of an *Orthis* much resembling *O. redux*. In America *N. elegans* belongs to the Lower Helderberg rocks. An allied form *N.* (*S.*) *pisum*, Sow., is not rare in our British Upper Silurian strata.

14. Athyris incerta, n. sp.? Pl. IV. fig. 12.

More or less pentagonal, rather wider than long; dorsal valve moderately convex; surface smooth, with a broad, slightly produced mesial fold, flattened or depressed along the middle; ventral valve convex; sinus shallow. Length 6, width 8 lines.

Of this species only one or two internal casts of the dorsal valve and an external impression have been met with by Mr. Vicary; it is therefore impossible, with such scanty materials, to even hint at a definite specific identification. It much resembles certain small Devonian specimens of *A. concentrica*, and also the Carboniferous *A. ambigua*, Sow. Some indeterminable impressions of an *Orthis* and of *Tentaculites* have been found along with it in the same pebble.

Internal casts of two more species, perhaps referable to this genus, have been found. They are not, however, sufficiently complete to admit of being specifically determined; but, for the sake of reference, I must give them a provisional denomination.

15. Athyris? budleighensis, n. sp.? Pl. IV. fig. 14.

Of this species the internal cast of a ventral valve has alone been discovered; it is almost circular, slightly wider than long—no markings being observable but two slits in the beak, due to dental plates. It measures, length 9, and width $9\frac{1}{2}$ lines, and was found by Mr. Vicary along with *Spirifera Verneuilii* and *Rhynchonella inaurita*. It is consequently a Devonian species.

16. Athyris? erratica, n. sp. Pl. IV. fig. 13.

Shell small, elongated, oval; valves moderately convex. Length 4, width 3, depth 2 lines.

The internal cast of one specimen was found by Mr. Vicary; we are not acquainted with its exterior.

17. Rhynchonella inaurita (Sandberger). Pl. V. figs. 1–3.

Brach. rheinischen Schicht. in Nassau, p. 41, pl. xxxiii. fig. 5, 1855.
Rhynchonella?, Salter, Quart. Journ. Geol. Soc. vol. xx. p. 296, pl. xvii. fig. 15.

Subtrigonal, wider than long, both valves convex; dorsal valve gibbous; mesial fold rising abruptly with greater or less width, and forming in profile a regular convex curve. In the ventral valve the sinus is broad and moderately deep, extending from the extremity of the beak to the front; beak incurved. Surface of each valve

ornamented with from sixteen to twenty simple angular ribs, of which from three to six of the largest occupy the fold, while from two to five furrow the sinus, the ribs on the lateral portions of the shell being narrower. Length 9, breadth 10, depth 6 lines.

In size, shape, and character this shell entirely resembles *R. inaurita*, Sandberger. It is also not unlike *R. daleidensis*, Roemer, and *R. livonica*, v. Buch, but seems to be distinguishable from both by the shape and character of its mesial fold, which is regularly incurved, and not recurved upwards near the front as is the case with the last two species. *R. inaurita* occurs abundantly under the condition of internal casts and external impressions, and is associated with *Sp. Verneuilii*, *R. Valpyana*, *Streptorhynchus crenistria*, *Productus Vicaryi*, and *Crania transversa*. It is consequently a well-defined Devonian species, and as such it was identified by M. de Verneuil in 1863.

In his paper on the Budleigh-Salterton fossils Mr. Salter describes and figures a single internal cast of the dorsal valve of this species, as well as the cast of what he takes to be another species; but as the last-named specimen has been lost or mislaid, I could not examine it, and consequently cannot express any opinion with reference to its claims as a separate species. I will therefore simply reproduce Mr. Salter's description.

"*Rhynchonella*, sp.," Quart. Journ. Geol. Soc. vol. xx. p. 297, pl. xvii. fig. 14.

"A remarkable fossil, which, if it were more perfect, should receive a name. It is singularly inflated, both on the sides and in the great dorsal fold, which occupies one-half of the width, and is $\frac{7}{10}$ inch long, and scarcely so wide, while the depth of the single dorsal valve we possess is $\frac{4}{10}$. The shape is broad-ovate, the beak much pointed and rather produced, the sides arched, inflated, and separated by a rather broad depressed space from the raised sinus, which has four strong plaits. The sides are only faintly ribbed. The front is strongly incurved."

18. Rhynchonella elliptica, Schnurr? Pl. V. fig. 4.

Along with *R. inaurita*, another similarly shaped shell is occasionally met with, which may perhaps be an extreme variation in form of the last-named species, but may be distinguished from it by a greater number of ribs on the mesial fold. It is nearly circular, or a little broader than long, and ornamented with about twenty-eight ribs on each valve, of which nine occupy a slightly raised mesial fold. Length 8, width $8\frac{1}{2}$ lines.

This is certainly a Devonian species, as it occurs in the same boulders with *R. inaurita* and *Spirifera Verneuilii*; we have provisionally identified it with *R. elliptica* of Schnurr?

19. Rhynchonella, sp.? Pl. V. figs. 5 & 6.

Of this species two internal casts have been found by Mr. Vicary; but, as no external impressions accompanied them, I dare not attempt their identification. In shape it is somewhat pentagonal, wider than

long, with from thirteen to sixteen ribs on each valve, of which from three to four compose a moderately raised mesial fold. It measures, length 7, width 8 lines. This is a Devonian shell, as it occurs with *Spirifera Verneuilii.*

20. Rhynchonella Valpyana, n. sp. Pl. IV. figs. 26 & 27.

Shell small, pentagonal, longitudinally oval or ovate; valves moderately convex; surface ornamented with about thirteen simple ribs, of which the three largest in the dorsal valve form the mesial fold. Length 5, width 4, depth 3 lines.

Two or three internal casts and an external impression have been found by Messrs. Valpy and Vicary. It is, I believe, of Devonian age.

21. Rhynchonella Vicaryi, n. sp. Pl. V. figs. 7 & 8.

Shell small, somewhat trigonal and compressed, longer than wide, broadest anteriorly, tapering at the beaks; front straight; valves moderately and uniformly convex; surface smooth to about half its length from the beaks. Each valve is ornamented with eight or nine short ribs, of which three or four compose the fold, and two or four the sinus; beak small. Length $5\frac{1}{2}$, width 5 lines.

Of this small species I have seen several internal casts and external impressions. It was found by Mr. Vicary in the same pebble with *Spirifera Verneuilii*, and is consequently of Devonian age. It much resembles some Lower-Silurian specimens of *R. Thomsoni*, but could not be with certainty identified with that species.

22. Rhynchonella? ovalis, n. sp. Pl. IV. figs. 24 & 25.

Shell small, as wide as long, or rather longer than wide; ventral valve almost uniformly convex, with from eighteen to twenty simple ribs; dorsal valve regularly convex and ornamented like the other valve. Two specimens measured:—

Length 3, breadth $2\frac{1}{2}$ lines.
" 3 " 3 "

Of this small species I have seen a few internal casts and external impressions, but not sufficiently numerous or perfect to enable me to give a complete description of the shell. It has been found by Mr. Vicary in company with *Orthis Vicaryi*, and *Strophomena budleighensis*, and is possibly of Silurian age.

23. Orthis redux, Barrande?, var. *budleighensis*. Pl. V. figs. 9–12.
Orthis redux, Barr.?, Salter, Quart. Journ. Geol. Soc. vol. xx. p. 295, pl. xvii. fig. 7, 1863; and Dav. Sil. Mon. p. 224, pl. xxviii. fig. 6, 1869.

Shell small, semicircular, wider than long, sometimes almost circular; hinge-line less than the width of the shell. Ventral valve moderately and uniformly convex, beak small, area narrow. Dorsal valve slightly convex, with a longitudinal depression of moderate depth along the middle. Surface of both valves closely covered with nume-

rous thread-like striæ, which increase in number by the interpolation of one or two smaller striæ between each pair of the principal. Dimensions variable. Length 5, width 6, depth 2 lines.

Although this shell was identified by Mr. Salter with *Orthis redux* (Barrande), both M. de Verneuil and myself entertain misgivings as to the correctness of the identification. The Bohemian Silurian species is not well known; the internal cast only has been figured by Barrande. It is a larger shell, and the median sinus is much deeper than what we find in our Budleigh examples. At any rate we have given to it the varietal designation of *Budleighensis*, which name can be hereafter retained as a specific one should the two shells be found to be specifically distinct. The correct identification of this species becomes very important, since no less than seven other forms have been found in the same pebbles with it. We therefore cannot determine at present whether it and its accompanying forms are of Silurian or of Devonian age.

24. Orthis Berthoisi, Rouault?, var. *erratica,* Dav. Pl. V. figs. 13–16.
Dav. Sil. Mon. p. 238, pl. xxxii. figs. 21–28.

This species has been fully described and illustrated at p. 233 of my Silurian Monograph. I cannot say whether it agrees with the *Orthis Berthoisi,* Rouault, as I have never seen the French type; nor can I say whether Mr. Sharpe was correct in identifying his Portuguese examples with Rouault's species. Budleigh specimens seem to resemble the Portuguese shell, while differing in some minor details; I have provisionally applied to them the varietal designation of *erratica.* Mr. Sharpe states that he obtained the fossil he identifies with *O. Berthoisi* from the lowest division of the Silurian system, at Portela de Loredo, in Portugal.

25. Orthis Valpyana, Dav. Pl. V. figs. 23–25.
Sil. Mon. p. 235, pl. xxxii. figs. 29–33.

A description of this shell will be found in my Silurian Monograph. Mr. Vicary informs me that he believes that he has found it associated with *O. Vicaryi* in the same pebble. It appears also to bear some resemblance to *O. Gervillei* (Defr. & Barr.); but there is sufficient difference between the two forms to consider them specifically distinct.

26. Orthis pulvinata, Salter. Pl. V. figs. 17–19.
Quart. Journ. Geol. Soc. vol. xx. p. 294, fig. 8, 1860.
? *Porambonites,* Salter, *ibid.* p. 295, pl. xvii. figs. 10–12.

Transversely oval; hinge-line shorter than the width of the shell; valves uniformly and moderately convex, surface marked by fine radiating lines or raised striæ, increasing in number towards the margin by the interpolation of shorter striæ. Area narrow. The internal cast of the ventral valve shows a large saucer-shaped muscular depression, divided in the middle by a widish convex ridge or space; in the internal cast of the dorsal valve there is a small oval slit,

margined by a raised edge, under which are placed the muscular (adductor) elevations or scars, which are longitudinally separated by a narrow concave space. Length 11, breadth 14 lines.

The internal cast of the dorsal valve was, in 1863, described and figured by Mr. Salter, the exterior and interior of the other valve being unknown to him at the time; subsequently, however, impressions of the exterior, as well as the internal cast of the ventral valve, were found by Mr. Vicary, so that it is now possible to draw up a complete description of the species. The shell described by Mr. Salter as *Porambonites*, sp.? (from the imperfect internal cast of a dorsal valve), appears to me to be a large internal cast of the shell under description, in which the muscular impressions are imperfectly defined; but I make this suggestion with reserve. The figure given by Mr. Salter is likewise not entirely correct. In the original specimen the cardinal angles are more rounded; and the muscular impressions, &c., are less sharply defined on the cast than they are in the figure; nor does it, or Mr. Sharpe's Portuguese specimens, to which it is assimilated, belong to the genus *Porambonites*.

I do not know whether it is a Silurian or a Devonian species, as no other known form has been found associated with it in the same pebble.

27. Orthis Vicaryi, n. sp. Pl. V. figs. 20–22.

Shell circular or elongated oval, slightly wider anteriorly; hinge-line straight, about half the breadth of the shell. Ventral valve moderately convex, beak slightly incurved, area narrow and small, divided in the middle by a rather wide fissure. Dorsal valve rather less convex than the opposite one. Surface of both valves marked by numerous fine thread-like radiating lines or raised striæ, which increase in number by means of numerous interpolations. In the interior of the ventral valve two large, deep, oval-shaped muscular depressions occupy fully two-thirds of the length of the valve, and are divided in the middle by a narrow, angular, slightly projecting ridge. In the interior of the dorsal valve a small, bilobed cardinal process is situated between the prominent, diverging, slightly curved brachial processes; while a rather wide, rounded mesial ridge extends from under the cardinal process to about half the length of the valve, and separates into two parts the muscular (adductor) impressions. Two specimens measured:—

Length 7, width 7 lines.
" 5 " 4 "

Of this species several examples have been found by Messrs. Vicary and Valpy. It occurs most frequently in the shape of internal casts; but impressions of the external surface are occasionally met with. It is remarkable on account of the large proportions of the elongated, oval-shaped muscular depressions in the ventral valve.

Along with this species is found a small *Rhynchonella*?, which, if *R. ovalis*, would perhaps indicate that the *Orthis* under description is Silurian; but the question of age will require to remain for the present undetermined.

Besides the species of *Orthis* above recorded, Mr. Vicary has sent me two or three impressions and internal casts, which cannot be referred to any of those above enumerated. The material was, however, too scanty and incomplete to warrant our attempting specific identifications.

28. Strophomena Rouaulti, n. sp. Pl. VI. figs. 8 & 9.

Shell semicircular, slightly wider than long; hinge-line straight, a little less than the width of the shell. Ventral valve very moderately convex, with a narrow area and open fissure. Dorsal valve almost flat, or very slightly concave. Exterior finely striated. In the interior of the ventral valve a small hinge-tooth is situated on either side of the base of the fissure, while the muscular scars form a large saucer-shaped depression laterally margined by a slightly elevated ridge. In the interior of the dorsal valve a wide raised border surrounds the shell; hinge-area linear. The cardinal process is composed of two testaceous projections, under which are located two elongated, parallel muscular impressions, surrounded by a narrow elevated ridge, and separated along the middle by a rather wide interspace. Length 10, width 11 lines.

This species appears to be rare, only a few internal casts of the two valves having been found by Mr. Vicary. As no other Brachiopod has occurred along with it, I cannot say whether it should be referred to the Silurian or to the Devonian series. In external form it bears much resemblance to more than one Silurian as well as Devonian species; but the shape of the muscular impressions in the dorsal valve seems to distinguish it from described species of the genus.

29. Strophomena Etheridgii, n. sp. Pl. VI. figs. 10–12.

Semicircular, as wide as or rather wider than long; hinge-line a little shorter than the width of the shell; ventral valve very slightly convex; area narrow, muscular impressions forming a large saucer-shaped depression, laterally margined by a slightly raised border, and longitudinally divided along the middle by a narrow ridge. In the interior of the ventral valve the hinge-area is linear, with a minute cardinal process in the centre; under this is situated a small oval-shaped depression, with another smaller pit on either side, while beyond these may be seen the small hollow for the reception of the teeth of the ventral valve. Under the three central depressions above described there exists a short, raised mesial ridge, broad at its origin, but becoming gradually attenuated as it approaches its anterior termination; between this and the hinge-line are seen two granular ovarian elevations. The muscular impressions are indistinct. External surface not known, in all probability finely striated. Length 11, width 12 lines.

Of this interesting species I have seen but two internal casts. It was found by Mr. Vicary along with *S. Edgelliana*; but I am uncertain as to its real age. Mr. Vicary believes that he has found *Rhynchonella ovalis* in the same pebble.

30. Strophomena Edgelliana, n. sp. Pl. VI. figs. 2–5.

Transversely semicircular, with expanded angular extremities; hinge-line as long as the greatest breadth of the shell; ventral valve slightly convex, area narrow, divided in the middle by a triangular fissure; dorsal valve very slightly convex, almost flat; surface of valves marked by numerous small bifurcating striæ. In the interior of the ventral valve there is a small tooth on either side at the base of the fissure, while the muscular impressions form a small saucer-shaped depression surrounded by a raised margin; this depression is about as wide as long, or about one-fourth of the width of shell, notched in front, and divided along the middle by a broad angular ridge. In the interior of the dorsal valve there exists a small bilobed cardinal process. Slightly projecting deviating socket-ridges are also visible. Under the cardinal process a raised hollow roof-like ridge extends to a little distance, prior to becoming forked; on either side of this ridge are situated the muscular scars. Length and breadth 11 lines.

Several internal casts, as well as external impressions of this interesting species have been found by Mr. Vicary associated with specimens of an *Orthis* resembling *O. redux*; consequently, if this last identification proves correct, *S. Edgelliana* would be of Silurian age. It bears, however, a good deal of resemblance to the Devonian *Leptæna Dutertrii* (Murch.), both in external shape and internal arrangements; but it differs sufficiently from this and *O. redux* to justify us in proposing for it a distinct specific designation. I have named it after Mr. Arthur Edgell, to whom we are indebted for the discovery of several interesting Budleigh specimens.

31. Strophomena Vicaryi, n. sp.? Pl. VI. figs. 6 & 7.

Shell transversely semicircular, regularly convex, with expanded angular extremities; hinge-line straight and long, with closely set perpendicular or slanting striæ; area narrow, divided by a triangular fissure; the muscular scars form two elongated depressions, divided by a raised mesial ridge; external surface marked by numerous thread-like striæ, two or three finer ones being placed between each pair of the larger striæ; dorsal valve not known. Length 8, breadth 11 lines.

Of this species we are at present acquainted with one valve only; and consequently a complete description of the shell cannot be drawn up. The shape of its muscular impressions, in the ventral valve, differs from that seen in *S. Edgelliana*. Mr. Salter has also expressed the opinion that the two are specifically distinct. It has been found by Mr. Vicary in company with *S. Etheridgii* and *Rhynch. ovalis*; its real age cannot, however, be at present accurately determined.

32. Strophomena budleighensis, n. sp.? Pl. VI. fig. 1.

Of this species a remarkable internal cast of the ventral valve only has been found. It is convex, semicircular, and about as wide as long; the hinge-line as long as or a little longer than the width

of the shell; area moderately wide, marked with perpendicular parallel lines, and with two deep circular pits (elevations on the cast), one on each side of the centre, divided by a small flattened space; the saucer-shaped muscular scars are large, and, in the shell, divided by a median ridge.

Mr. Vicary found this single specimen associated with *R. ovalis.* The peculiar shape of its area and accompanying pits seems to distinguish it from other known forms of the genus, although it is impossible to offer a complete description of its characters.

33. Streptorhynchus crenistria, Phil. Pl. V. fig. 26.
Spirifer crenistria, Phil. Geol. of Yorkshire, vol. ii. p. 216, pl. 9. fig. 6; *Streptorhynchus crenistria,* Dav. Dev. Mon. p. 81, pl. xviii. fig. 7.

Of this species, only a fragment of the exterior of one valve has been found. It seems to agree entirely with similar portions of *S. crenistria,* with which we have compared it. The shell has been fully described in my monograph. It was found along with *Spirifera Verneuilii, Rhynchonella inaurita,* and *Productus Vicaryi,* and is consequently a Devonian species.

34. Productus Vicaryi, Salter, sp. Pl. VI. fig. 14.
Leptæna Vicaryi, Salter, Quart. Journ. Geol. Soc. vol. xx. p. 296, pl. xvii. figs. 16–17.

Well described and figured by Mr. Salter, but incorrectly identified as a *Leptæna,* while all its external and internal characters show it to be a *Productus*; in addition to the cardinal spines, we find the large cardinal or divaricator muscular impressions of the genus *Productus.* These finely striated scars were correctly drawn by Mr. Salter in 1864. In his description he states, "I know no Silurian species, except the small *L. quadrata* of Russia, and *L. tenuicincta* of Britain, which resemble this form; both are much smaller and less gibbous." But these last belong to the genus *Leptæna,* and are quite different both as to shape and character, while the so-called *Leptæna Vicaryi* is a well-characterized *Productus. P. Vicaryi* is not very rare at Budleigh-Salterton, and is found associated with *Spirifera Verneuilii, Rhynchonella inaurita,* and *Streptorhynchus crenistria,* all well-known Devonian species.

35. Chonetes, sp. Pl. VI. fig. 13.

Of this small species of *Chonetes* several specimens have been met with by Messrs. Edgell and Vicary in one or two pebbles; and as it was associated with *Rhynchonella inaurita,* it is no doubt of Devonian age; but as the exterior has not been discovered, we cannot refer it with certainty to any of the described species. The casts are marginally semicircular; hinge-line straight, with acute, slightly projecting cardinal angles; ventral valve evenly convex. Length 3, width 4 lines. In external shape it resembles some Devonian casts of *C. hardrensis,* but is a smaller shell.

Besides the species above enumerated, Mr. Vicary has found in-

complete specimens, evidently belonging to two or three more forms, but which cannot be specifically identified until more complete material shall have been procured. Among these may be mentioned two valves, which are perhaps referable to the genus *Atrypa*. One of the specimens measures sixteen lines in length by fifteen in breadth, is uniformly convex, without fold or sinus, and is marked with numerous close radiating striæ.

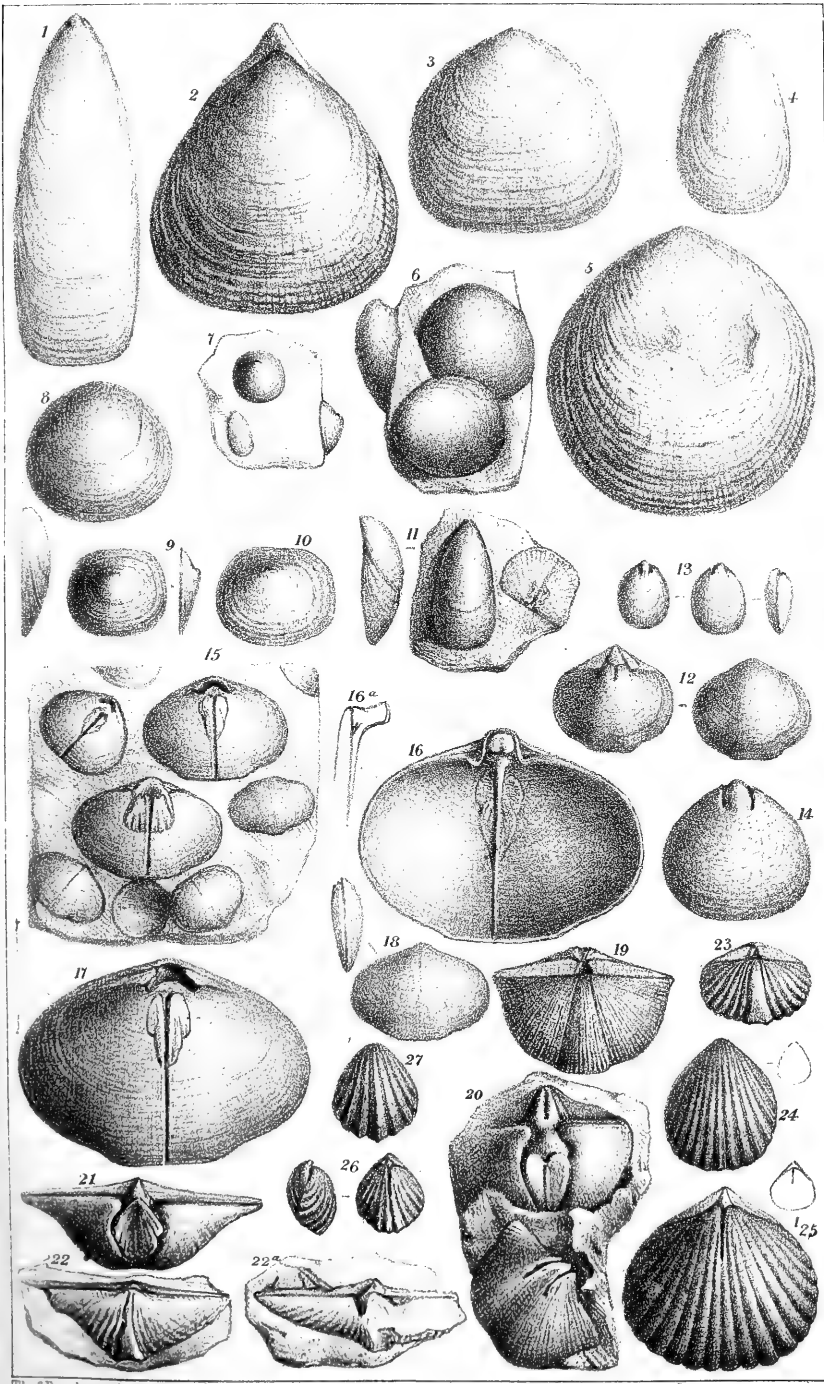
EXPLANATION OF PLATES IV.–VI.

Plate IV.

Fig. 1. *Lingula Lesueuri*, Rouault.
2. —— *Rouaulti*, Salter.
3. —— *Hawkei*, Rouault.
4. ——, sp.?
5. —— *Salteri*, Dav.
6. *Discina Vicaryi*, Dav.
7. —— *incerta*, Dav.
8. —— ? *Edgelli*, Dav.
9, 10. *Crania transversa*, Dav.
11. *Terebratula*, sp.?
12. *Athyris incerta*, Dav.
13. —— ? *erratica*, Dav.
14. —— ? *budleighensis*, Dav.
15. *Nucleospira Vicaryi*, Dav.
16. —— ——. Interior of dorsal valve, enlarged.
17. —— ——. Internal cast of same valve, enlarged.
18. —— ——. Both valves united, seen in profile.
19. *Spirifera Verneuilii*, Murch.
20. —— ——. Internal casts.
21. —— *macroptera*, var. *microptera*. Internal cast.
22. —— —— ——. Shell.
23. —— *octoplicata*, Sow.
24, 25. *Rhynchonella? ovalis*, Dav.
26, 27. —— *Valpyana*, Dav.

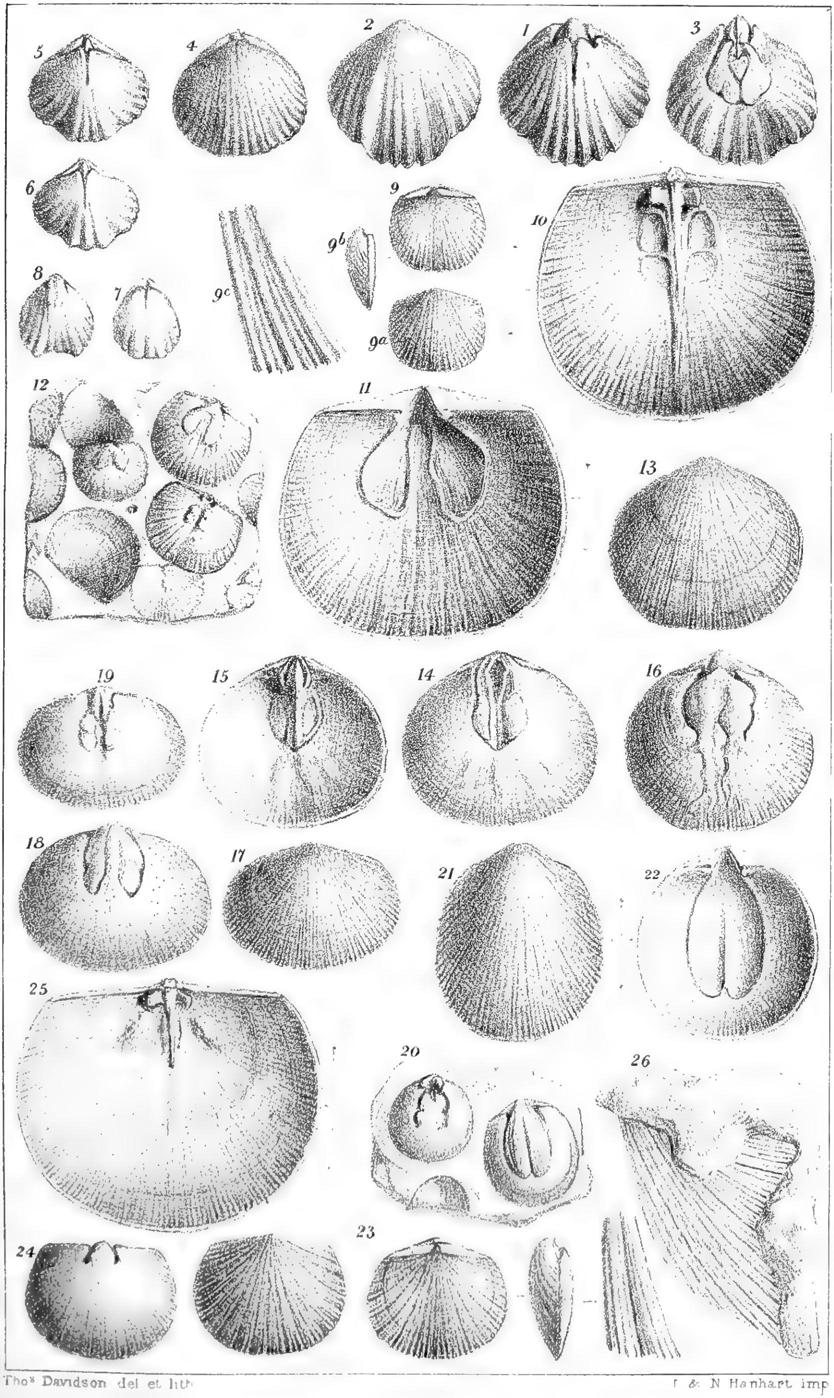
Plate V.

Fig. 1, 2, 3. *Rhynchonella inaurita*, Sandb. Internal casts.
4. —— *elliptica*, Schnurr?
5, 6. ——, sp. Internal casts.
7, 8. —— *Vicaryi*, Dav.?
9. *Orthis redux*, Barr.? var. *budleighensis*.
10. —— ——. Interior of dorsal valve, enlarged.
11. —— ——. Interior of ventral valve, enlarged.
12. —— ——. Internal casts, natural size.
13. —— *Berthoisi*? var. *erratica*, Dav.
14. —— ——. Internal cast of dorsal valve.
15. —— ——. Interior of same valve.
16. —— ——. Internal cast of ventral valve.
17. —— *pulvinata*, Salter. Exterior.
18. —— ——. Internal cast of ventral valve.
19. —— ——. Internal cast of dorsal valve.
20. —— *Vicaryi*, Dav. Internal casts of both valves, natural size.
21. —— ——. Exterior, enlarged.
22. —— ——. Interior of ventral valve, enlarged.
23. —— *Valpyana*, Dav. Exterior, natural size.
24. —— ——. Internal cast of ventral valve.
25. —— ——. Interior of dorsal valve, enlarged.
26. *Streptorhynchus crenistria*, Phil.



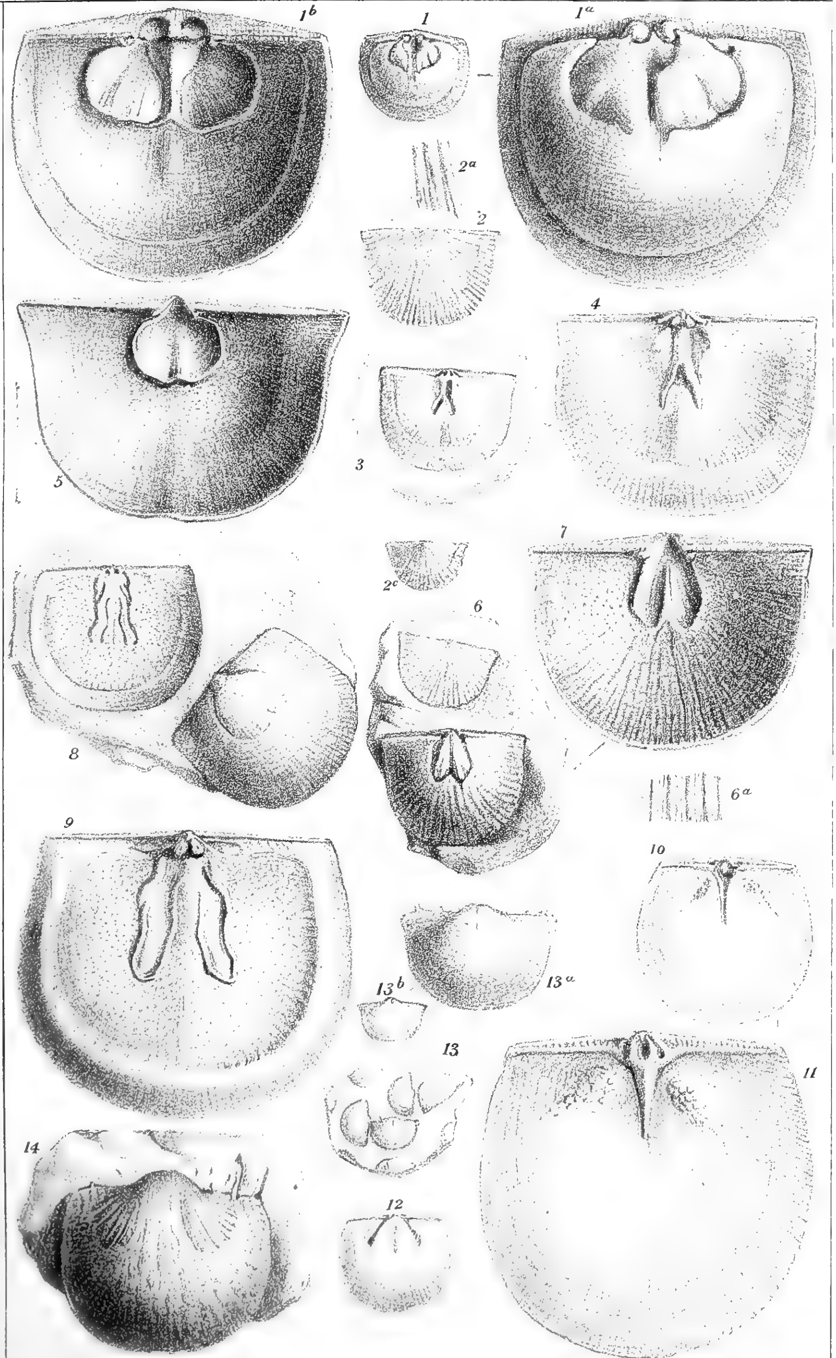
Thos. Davidson del. et lith.

M. & N. Hanhart imp.



Thos Davidson del et lith

I & N Hanhart imp



Thos Davidson del et lith

M & N Hanhart imp

PLATE VI.

Fig. 1. *Strophomena budleighensis*, Dav. Internal cast of ventral valve, natural size.
1a. —— ——. The same, enlarged.
1b. —— ——. Interior of same valve, taken by means of gutta percha from cast.
2. *Strophomena Edgelliana*, Dav. Exterior of dorsal valve.
3. —— ——. Internal cast of dorsal valve, natural size.
4. —— ——. Interior of dorsal valve, enlarged.
5. —— ——. Interior of ventral valve, enlarged.
6. —— *Vicaryi*, Dav. Natural size.
7. —— ——. Interior of ventral valve, enlarged.
8. —— *Rouaulti*, Dav. Internal cast of both valves, natural size.
9. —— ——. Interior of dorsal valve, enlarged.
10. —— *Etheridgii*, Dav. Internal cast of dorsal valve, natural size.
11. —— ——. Interior of dorsal valve, enlarged.
12. —— ——. Internal cast of ventral valve.
13. *Chonetes*, sp.? Internal cast, natural size.
13a. —— ——? Enlarged cast.
14. *Productus* (*Leptæna*) *Vicaryi*, Salter, sp. Internal cast of ventral valve, showing cardinal spines and large muscular scars.

DISCUSSION.

Mr. ETHERIDGE agreed with Mr. Davidson as to his determination of the species. He had, however, examined the extensive collection of Mr. Vicary, and, from the general *facies* of the species, he was inclined to assign them to the Middle Devonian and Lower Carboniferous beds. The attribution of the fossils to the Upper Llandovery beds was founded on the presence of *Lingula crumena*, &c.; but he thought he could give some clue to the locality from which the pebbles had been derived. It had at first, from the lithological character of the pebbles as well as from the fossils, been thought that they were of Lower-Caradoc age. He himself assigned the rocks from which the pebbles had been derived to the Hangman group of North Devon. At Anstey's Cove Mr. Tawney had lately found a series of the same class of fossils in a matrix exactly like that of the pebbles. He had examined the spot, and there recognized with Mr. Tawney an extension of the sandstones of North Devon (the Hangman Grits) on the south coast; and certainly, so far as lithological character was concerned, the rocks were the same as the pebbles. It did not, however, follow that all the pebbles came from that particular district, but probably from the denudation of the large tract of country of Devonian age to the north. There are, however, Silurian species in certain of the pebbles, and these he would refer to the denudation of rocks in an area mainly to the south of what is now the Devon coast. The fauna at Budleigh-Salterton is essentially British, and not French, though some few species are common to both areas. The bivalves, indeed, are hardly known in France. On the whole, Mr. Etheridge concluded that the fossils in the pebbles were Devonian, with a slight admixture of Silurian and probably Carboniferous forms, derived from rocks at no great distance from the spot where the pebbles are found.

Prof. RAMSAY pointed out that in conglomerates we might expect

to find pebbles of rocks of various ages. He commented on the difficulty palæontologists seemed to labour under in determining a fossil if it came out of a pebble instead of from a rock the position of which was definitely known. He adverted to the statement that the beds containing the pebbles had been deposited in the New-Red-Sandstone sea, whereas Mr. Godwin-Austen had regarded the New Red deposits as formed in large inland lakes; and the local character of the beds supported this latter view.

Dr. Duncan defended the caution of palæontologists, and remarked on the uncertainty attending the determination of casts.

Mr. Prestwich was glad that some other source had been suggested for the quartzite pebbles. He had found somewhat similar quartzites between Lisieux and Cherbourg, in France.

The President observed that he would like to see the rise of a new race of palæontologists relying simply on zoological characteristics, and not on geological position. A considerable simplification of our classification would probably result.

Mr. Etheridge briefly replied.

---

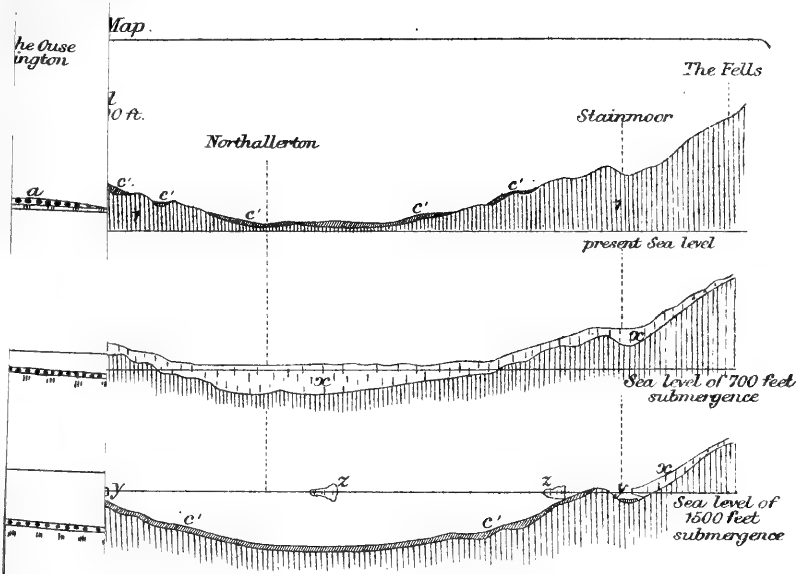
2. *On the* Relation *of the* Boulder-clay, *without* Chalk, *of the* North *of* England *to the* Great Chalky Boulder-clay *of the* South. By Searles V. Wood, Jun., Esq., F.G.S.

Plate VII.

In a paper read before this Society by myself and the Rev. J. L. Rome, F.G.S., and published in the Journal, we described the Glacial clay of the Yorkshire coast as consisting of two main parts*. Of these, the lower, distinguished both in our sections and in the vertical section accompanying the present paper (see Pl. VII.) by the letter *a*, presents characters identical in all respects with the ordinary Boulder-clay, with chalk as its prevailing constituent, which forms the uppermost member of the Glacial series of the east and east centre of England; while the upper (*c*) is a purple clay, in which chalk is only a subordinate constituent, even in the lower part, and which, gradually losing its chalk upwards, is in the upper part entirely destitute of it. We also endeavoured to show that, north of Flamborough Head, the whole of the clay, (which is destitute of chalk), belonged to this upper part only—and that, though lying at the foot of the northern escarpment of the chalk, as well as enveloping both the escarpment and the Wold, this clay, thus destitute of chalk, was not deposited until, by the complete submergence of the Wold, all source of chalk débris had been removed. We also suggested that the absence of any clay with chalk débris in these parts was due to their having been occupied by ice during the time that the clay containing that material was accumulated, and to this ice not having been removed until the Wold had been completely covered by the sea; and we identified this chalk-

* Vol. xxiv. p. 146. The Hessle clay there described is a separate deposit from the *Glacial* clay referred to in the paper, and is regarded by us as of *Post-glacial* age.

Map.



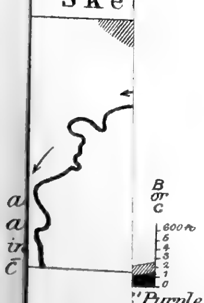
ns older

iddle Glacial. a The Chalky Clay.

ith Chalk

Floating Ice.

Ske

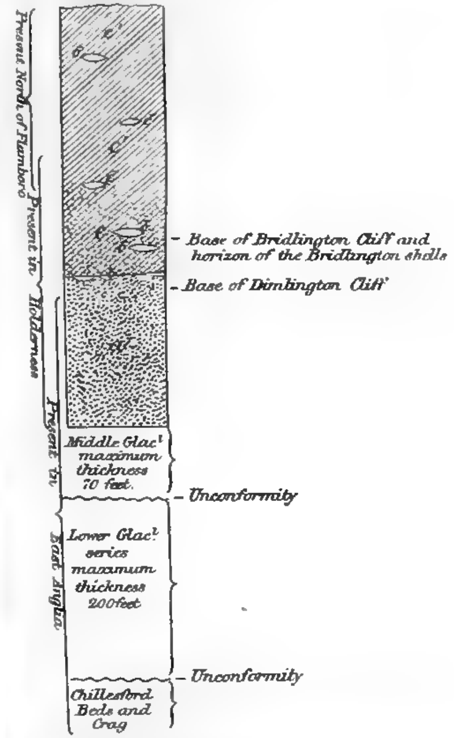


'Purple Clay without Chalk

F. Dangerfield lith: 22 Bedford S^t. Covent Garden.

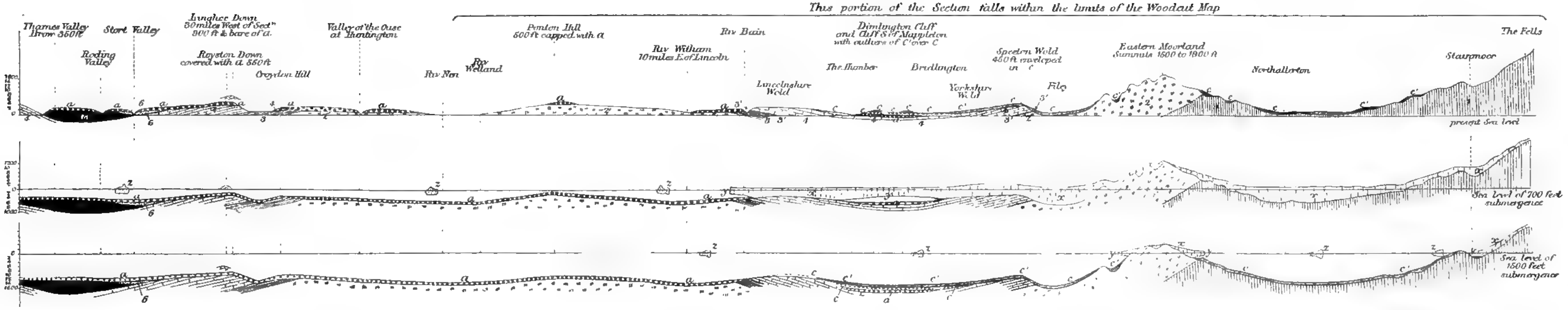
(Vertical) Section No. 1.

N.B. The Hessle beds omitted.



a The Chalky Clay. b Beds of Sand and alternations of a and C — C The purple Clay with chalk diminishing in quantity upwards — C' The purple Clay without Chalk. б Sand and Gravel intercalations in C and C'.

(Triple) Section No. 3.



Reference. *1 Various formations older than the Oolites. 2 Oolitic series 3 The lower Cretaceous series and Gault 3' The red Chalk 4 The Chalk. 5 The lower Tertiaries 6 The middle Glacial a The Chalky Clay*

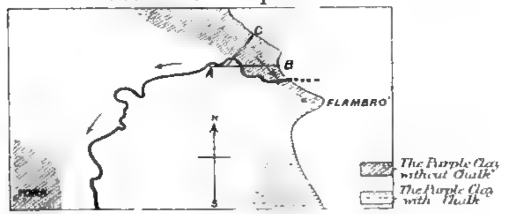
C The purple Clay with Chalk that diminishes in quantity upwards. C' The purple Clay without Chalk and with Shap boulders x The Ice sheet. y The Ice Foot z Floating Ice

The Hessle and other Post Glacial beds omitted.

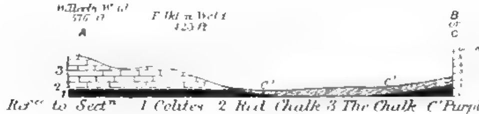
Sketch Map

The broken line indicates the former extension of the escarpment before its destruction by the Sea. The strong irregular line indicates the escarpment and northern boundary of the Chalk in Britain.

Scale 20 Miles to the Inch



Section 2.



Ref^ce to Sect^n 1 Oolites 2 Red Chalk 3 The Chalk C' Purple Clay without Chalk
Length of Section six miles

less clay of the north of Flamborough with a similar clay, also wholly destitute of chalk, of which outliers cap the purple clay with some chalk in Holderness, where, as at Dimlington and near Mappleton, the cliff-section shows the Glacial series to have undergone less denudation than elsewhere along that coast. We further pointed out that the long-known fossiliferous bed of Bridlington belonged to the Yorkshire Glacial formation; and we placed its horizon immediately superior to the chalky clay (*a*)—that is to say, in the lower part of the purple clay, wherein there is chalk, and at the horizon indicated in the accompanying vertical section (Pl. VII. fig. 1).

Now, while in Yorkshire we find the Glacial clay exhibiting the distinct feature of a gradual decrease and final disappearance of the chalk débris, succeeded by a deposit of considerable thickness, in which there is not a trace of chalk, the whole of the beds of the east and east centre of England indicate not only that débris from the chalk prevails throughout the series, but that it is to the full as copious in the uppermost layer that denudation has spared of the highest member of the series there as it is in the lowest.

It is therefore only with the highest member of that series, the common wide-spread Boulder-clay of East Anglia, that I propose to discuss the relationship borne by the Yorkshire Boulder-clay. As regards the very considerable and, I think, important series of deposits which are older than this wide-spread Boulder-clay, but are absent in Yorkshire and the north, I shall only have occasion to refer to them to the extent of pointing out the great distinction existing between their fauna and that of the bed at Bridlington, and of indicating their place in the vertical section accompanying this paper, as the structure and distribution of these older series will, I hope, form the subject of a future communication by myself and Mr. F. W. Harmer, F.G.S., who has cooperated with me in working them out.

The particulars of the considerable fauna obtained from Bridlington, and of the fauna collected from the Middle and Lower Glacial deposits of East Anglia, have received much attention from my father, and they will be tabulated by him with the fauna from the several horizons of the Crag and from the Postglacial beds of the eastern side of England, in his supplement to the Monograph of the Crag Mollusca. In the meantime, however, for the purposes of this paper, and to show, on the one hand, how entirely distinct these deposits are in their palæontological aspects from that of Bridlington, and, on the other, how closely they are connected in those aspects with the Crag, the following list, embodying our results up to the present time, as far as they concern the beds under consideration here, has been revised by him*:—

* The fauna of the Lower Glacial has been obtained with the assistance of Mr. Harmer, and that of the Middle Glacial with the same assistance and with that of Mr. E. T. Dowson, of Geldeston; while Mr. Leckenby has rendered my father most valuable assistance in verifying the Bridlington shells.

Name of the Shell.	Lower Glacial.	Middle Glacial.	Bridlington (or Upper Glacial).	Crag.	Living or extinct: see note at foot of list.	Remarks.
Buccinum undatum, *Linn.*	*	*	*	*	B, A, S.	
Tritonium antiquum, var. carinatum	...	...	*	*	A.	On authority of Woodward's list.
—— ——, var. carinatum contrarium	...	...	*	*	O.	
—— ——, var. striatum	*	*	...	*	B, A, S.	
—— ——, var. striatum contrarium	*	...	...	*	B, A, S.	Nearly extinct.
—— propinquum, *Alder*	...	...	*	*	B.	
—— consociale, *S. Wood*	...	*	...	*	O.	
—— gracile, *Dacosta*	...	...	*	*	B, A.	Behring's Straits also.
—— ventricosum, *Gray*	...	...	*	...	A.	
—— Sabini, *Hancock*	...	...	*	...	A.	Not the *T. Sabini* of Gray.
Trophon clathratus, *Strom.*	...	...	*	*	A.	Probably the *Fusus scalariformis* of Woodward's list.
—— Gunneri, *Lovén*	...	...	*	?	B.	Given in Woodward's list as from Norwich crag; *sed quære*, Norway coast?
—— muricatus, *Mont.*	...	*	...	*	B, S.	
—— truncatus, *Strom.*	...	...	*	?	B.	*Fusus clathratus* of Woodward's list? *M. Bamfius* of the Clyde beds.
—— craticulatus, *O. Fab.*	...	...	*	...	A.	*T. Fabricii* of Woodward's list?
Trophon?, new species	...	*	...	...	O.	Three specimens of a shell half an inch in length. It comes nearest to a minute representation of *Trophon costiferum.*
Purpura lapillus, *Linn.*	*	*	*	*	B, A, S.	
—— var. incrassata	...	*	...	*	O.	
Columbella Holböllii, *Möll.*	...	...	*	...	B, A.	Not found south of Shetland.
Nassa incrassata, *Müll.*	...	*	...	*	B, S.	
—— granulata, *J. Sow.*	...	*	...	*	O.	Not uncommon in Middle Glacial.
—— reticosa, *J. Sow.*, var. costata	...	*	...	*	O.	
—— pusilla? *Phil.*	...	*	...	*	O.	A (somewhat rare) shell of the Red and Fluvio-Marine Crag, but common in the Middle Glacial, seems, from Philippi's figure, to be this species. It will be figured in the supplement to the 'Crag Mollusca.'
——, new species?	...	*	...	...	O.	Several specimens from the Middle Glacial.
Mangelia turricula, *Mont.*	..	*	*	*	B, A.	
—— Trevelliana, *Turt.*	...	...	*	*	B, A.	
—— cylindracea? *Möll.*	...	...	?	...	A.	Given on authority of Woodward's list. The shell cannot be found.
—— cinerea, *Möll.*	...	...	?	...	A.	On authority of Woodward's list.
—— exarata, *Möll.*	...	...	*	*	A.	
—— elegans, *Möll.*	...	...	*	...	A.	
—— nobilis, *Möll.*	...	...	*	...	A.	
—— pyramidalis, *Strom.*	...	...	*	*	A.	*M. Vahlii*, sec. Jeffreys.

Name of the Shell.	Lower Glacial.	Middle Glacial.	Bridlington (or Upper Glacial).	Crag.	Living or extinct: see note at foot of list.	Remarks.
Mangelia linearis ?, *Mont.*	...	*	...	*	B, S.	The Middle-Glacial shell departs from the Crag *linearis* in being less slender, and in having more numerous costæ.
Cancellaria viridula, *O. Fab.* ...	...	...	*	*	A.	*Admete viridula* of Woodward's list. *C. costellifera*, J. Sow., of 'Crag Mollusca.'
Trichotropis borealis, *Brod. & Sow.*	...	...	*	?	B, A.	This species occurs in the Coralline Crag only; but the Coralline-Crag form is a very distinct variety from the Bridlington shell.
Natica clausa, *Brod. & Sow.* ...	*	*	*	*	A.	
—— Montagui, *Forbes*...........	...	...	*	...	B, S.	Iceland and Norway also. Naples, sec. Jeffreys.
—— grœnlandica, *Beck*	...	...	*	?	B, A.	
—— occlusa, *S. Wood*	...	...	*	*	A ?	Recently identified by Mr. Jeffreys with a Spitzbergen shell.
—— helicoides, *Johnston*.........	*	...	*	*	B, A.	
—— catena, *Dacosta*	*	*	...	*	B, S.	
Scalaria grœnlandica, *Chemn.* ...	*	...	*	*	A.	
—— Trevelyana ? *Leach*	...	*	...	...	B, S.	The Middle-Glacial specimen is too broken for certain identification.
Turritella polaris, *Beck*	...	...	*	...	A.	*T. erosa* of 'Crag Mollusca' and of Woodward's list. *T. clathratula* of 'Crag Mollusca.'
—— incrassata, *J. Sow.*	...	*	...	*	O.	Very abundant in Middle Glacial.
—— terebra, *Linn.*	...	*	*	*	B, S.	*T. communis* of 'Crag Mollusca' and of Woodward's Bridlington list; one fragment only from Middle Glacial. Mr. Leckenby knows no other form of *Turritella* from Bridlington than *T. erosa.* Given therefore on the authority of Woodward's list. Very rare in Crag.
Chemnitzia internodula, *S. Wood*	...	*	...	*	O ?	Several broken specimens from the Middle Glacial. Said by Mr. Jeffreys to have recently been dredged living.
Odostomia unidentata, *Mont.* ...	...	*	...	*	B.	Unique in Crag. One specimen, with mouth perfect, from Middle Glacial.
Rissoa obsoleta, *S. Wood*.........	...	*	...	*	O.	Coralline Crag only.
—— semicostata ? *Woodward* ...	...	*	...	?	O.	Two specimens from the Middle Glacial, but too imperfect to show whether they be the extinct *R. semicostata*, with the denticulated lip, of the Crag, or the living *R. inconspicua*, a B, S form.
Littorina littorea, *Linn.*	*	*	*	*	B, A, S.	
—— rudis, *Maton & R.*	*	*	...	*	B, A, S.	

Name of the Shell.	Lower Glacial.	Middle Glacial.	Bridlington (or Upper Glacial).	Crag.	Living or extinct: see note at foot of list.	Remarks.
Margarita elegantissima, *Bean* ..	...	...	*	...	A.	*M. plicata*, Sars.
Cemoria Noachina, *Linn*.	...	...	*	...	B, A.	*Puncturella Noachina* of Forb. & Hanl., and of Jeffreys.
Calyptræa chinensis, *Linn*.	...	*	...	*	B, S.	One young specimen from the Middle Glacial.
Dentalium abyssorum, *Sars*	...	...	*	...	A.	
—— ——, var. tarentinum	...	...	*	...	B.	
—— dentalis? *Linn*.	...	*	...	*	S.	*D. costatum*, J. Sow. Two specimens from the Middle Glacial. The costæ are as broad as, but less prominent than, in the Crag shell; but this may be due to wear. It is possible that the specimens may be only the upper portions of *D. abyssorum*.
Rhynchonella psittacea, *Chemn*.	...	...	*	*	A.	
Anomia ephippium, *Linn*.	...	*	*	*	B, S.	*A. squamula* of Woodward's list. Common in Middle Glacial.
—— striata, *Brocc*.	*	...	...	*	B ?	Sitka and Norway.
Ostrea edulis, *Linn*.	...	*	...	*	B, S.	Lower beds of Red Crag only. Middle Glacial of Stevenage, Herts, only.
Pecten opercularis, *Linn*	...	*	...	*	B, S.	Very common in Middle Glacial, but fragmentary.
—— islandicus, *Müll*.	...	...	*	...	A.	
—— pusio, *Pennant*	...	...	?	*	B, S.	A specimen in Brit. Mus. said to be from Bridlington.
Mytilus edulis, *Linn*.	*	*	*	*	B, A, S.	Worldwide.
Modiola modiolus, *Linn*.	...	...	*	*	B, A.	*M. vulgaris* of Woodward's list.
Pinna pectinata, *Linn*	*	*	*	*	B, S.	Fragments in Cromer Till.
Pectunculus glycimeris, *Linn*	...	*	...	*	B, S.	Very common, but small, in Middle Glacial; dies out in the upper beds of the Crag.
Arca lactea, *Linn*	...	?	...	*	B, S.	The hinge of the Middle-Glacial (perfect but small) specimen is too worn for certain identification.
Nucula Cobboldiæ, *J. Sow*.	*	*	*	*	O, P.	The Lower- and Middle-Glacial and Bridlington specimens show a tendency to depart from the Crag form in having the peculiar ornamentation more confined to the upper and central part of the shell. Represented by *N. Lyalli* on the N.W. coast of America.
—— tenuis, *Mont*.	...	...	*	*	B, A, S.	
Leda limatula, *Say*	*	*	*	*	A.	*Yoldia oblongoides* of Woodward's [list.
—— pernula, *Müll*.	...	...	*	...	A.	British also?
—— myalis, *Couthouy*	*	...	...	*	N. A.	Three specimens in Brit. Mus., two from Postwick, a Crag locality, and one from Runton, which (except the forest freshwater bed) is Lower Glacial only.

Name of the Shell.	Lower Glacial.	Middle Glacial.	Bridlington (or Upper Glacial).	Crag.	Living or extinct: see note at foot of list.	Remarks.
Leda caudata, *Donov.*	...	...	*	*	B, A.	*L. minuta* of 'Crag Mollusca.'
Cardium edule, *Linn.*	*	*	*	*	B, A, S.	
—— islandicum, *Linn.*	...	..	?	...	A.	Given in Woodward's list; but the fragments in the British Museum are not sufficient for reliable identification.
—— norvegicum, *Spengl.*	...	*	...	...	B.	*Breydon (Bradwell cutting), sec. Jeff. vol. ii. p. 296 of Brit. Moll.
—— grœnlandicum, *Chemn.*	*	*	...	*	A.	
Cardita analis, *Phil.*	...	...	*	...	O.	The Bridlington shell called *C. scalaris* by Forbes, in Mem. Geol. Survey for 1846, was most probably only *C. analis*.
—— scalaris, *Leathes*	...	*	...	*	O, P.	Probably represented by *C. ventricosa*, Gould, on N.W. coast of America.
Lucina borealis, *Linn.*	*	*	...	*	B, A, S.	
Astarte borealis, *Chemn.*	*	*	*	*	A.	
—— ——, var. Withami	...	...	*	...	O.	
—— ——, var. semisulcata	...	...	?	...	A.	On authority of Woodward's list only. Believed by S. Wood to be only *A. sulcata*, var. *elliptica*.
—— mutabilis, *S. Wood*	...	...	*	*	O.	
—— sulcata, *Dacosta*	...	*	*	*	B, A, S.	Rare in Crag. Common in Middle Glacial. Mediterranean, sec. Jeffreys.
—— ——, var. elliptica	...	*	*	?	B, A.	*Bradwell. Given from Crag only on authority of Woodward's Norwich Crag list.
—— crebricostata, *Forbes*	...	...	*	...	A.	"North of Hebrides, in cold area, 550 fathoms," sec. Jeffreys.
—— compressa, *Mont.*	*	*	*	*	B, A.	
Woodia digitaria, *Linn.*	...	*	...	*	S.	Two imperfect specimens from Middle Glacial.
Tapes virgineus, *Linn.* } —— pullastra, *W. Wood* }	...	*	...	*	B, S.	Hinge-fragments of one or other or both of these species common in Middle Glacial; but which of them, cannot be said. Both in Crag and B, S.
Cyprina islandica, *Linn.*	*	*	*	*	B, A, S.	
—— rustica, *J. Sow.*	...	?	...	*	O.	* Bradwell.
Venus fluctuosa, *Gould*	...	...	*	...	N. A.	
—— fasciata, *Donovan*	...	*	...	*	B, S.	Abundant in Middle Glacial. Japan, sec. Jeffreys.
—— ovata, *Penn.*	...	*	...	*	B, S.	Profuse in Coralline Crag; rare in Red: three imperfect specimens from Middle Glacial.
Tellina lata, *Gmel.*	*	?	*	*	A.	*T. calcarea* of Wahl. A few doubtful fragments only from Middle Glacial. Rare in Red Crag, profuse in Fluvio-marine Crag and Chillesford beds.
—— obliqua, *J. Sow.*	*	*	*	*	O.	Profuse in all Crag beds and in Lower Glacial; not common in Middle Glacial. Only one specimen known from Bridlington.

Name of the Shell.	Lower Glacial.	Middle Glacial.	Bridlington (or Upper Glacial).	Crag.	Living or extinct: see note at foot of list.	Remarks.
Tellina prætenuis, *Leathes*	*	...	...	*	O.	Profuse in Red and Fluvio-marine crag and Chillesford beds. Rare in Lower Glacial.
—— balthica, *Linn.*	*	*	*	...	B, A, S.	Profuse in Lower and Middle Glacial, and in all Glacial and Postglacial beds.
—— crassa, *Gmelin*	...	*	...	*	B, S.	Common in Crag, and fragments. Common in Middle Glacial.
Donax vittatus, *Dacosta*	*	...	...	*	B, S.	
Scrobicularia plana, *Dacosta* ...	*	*	...	*	B, S.	*S. piperata*, Gmel. Hinge-fragments common in Middle Glacial.
Mactra ovalis, *Sow.*	*	*	*	*	B, A, S.	*M. elliptica* of British authors.
—— subtruncata, *Dacosta*	...	*	...	*	B, S.	*Bradwell.
—— solida, *Linn.*..................	...	?	...	*	B, S.	Doubtful fragments only, in Middle Glacial.
Thracia papyracea, *Poli*	*	...	...	*	B, S.	One perfect specimen from Lower Glacial.
Mya truncata, *Linn.*	*	?	*	*	B, A, S.	
—— arenaria, *Linn.*	*	*	*	*	B, A, S.	
Panopæa norvegica, *Spengl.* ...	...	...	*	*	B, A.	
Saxicava rugosa, *Linn.*	*	*	...	*	B, A, S.	
—— arctica, *Linn.*	...	...	*	...	A.	The gigantic form of Uddevalla and the Clyde beds.
Pholas crispata, *Linn.*	*	*	*	*	B, A.	
Corbula striata, *Walk. & B.*......	*	*	...	*	B.	*C. gibba*, Oliv. Profuse in Coralline and Fluvio-marine Crags, Chillesford bed and Lower Glacial. Common in Middle Glacial. Rare in Red Crag.

Note.—O, P signifies that the form is extinct unless represented by a Pacific shell; O, not known living; N. A, occurs no nearer than North-east America; A, only within the Arctic Circle; S, only to the south of the British Seas; B, A, S, in British, Arctic, and Southern Seas; B, A, in British and Arctic Seas only; B, in British Seas only, the Norway coast being included under this letter. The shells marked * Bradwell are inserted in the Middle-Glacial column on the authority of a list of identifications made by Mr. Gwyn Jeffreys of some shells and fragments obtained by Mr. G. B. Rose from the Middle-Glacial cutting of Bradwell (by Breydon), supplied by Mr. Rose.

N.B. In the foregoing list the Crag column embraces all the divisions of that formation from the Coralline Crag up to, and inclusive of, the Chillesford beds.

SUMMARY.

	O.	O, P.	B, S.	B, A.	B, A, S.	B.	S.	A.	N. A.	Total.
Lower-Glacial Shells	2	1	5	3	15	2	—	6	1	35
Middle ditto	13	2	19	4	15	3	2	5	—	63
Upper ditto (Bridlington)..	5	1	4	15	11	5	—	28	1	70

N.B. In the case of the Middle-Glacial shells, the number in column O is swelled by the two new shells and by two marked with ? being included in it.

A considerable number of these shells have been found living at depths ranging down to 100 and even 150 fathoms; our knowledge of the range of the others is, for the most part, merely negative.

From the foregoing list it appears that the Bridlington fauna consists of 70 forms of mollusca. Of these, after discarding all with regard to which there is any doubt, either as to their occurrence at Bridlington or as to their representation in the Crag, but including the distinct variety of *Trichotropis borealis*, no less than 19 are unknown to the Crag.

These 19 comprise 13 purely Arctic, 1 British and Arctic, 1 British, 1 British, Arctic, and Southern, and 1 North-American, and 2 not known as living.

The mollusca hitherto obtained from the Middle Glacial, *i.e.* from the sands and gravels which, overlying the Cromer contorted drift in the north of Norfolk, pass under the great chalky Boulder-clay of which I have been speaking in other parts of that county and in North Suffolk, in Essex, Herts, Buckingham-, and Leicestershires, and some other localities, comprise 63 forms, all but one of them collected within a radius of a few miles around Yarmouth, from the sands (where they are *in situ*) between the contorted drift and the great chalky Boulder-clay. Of these 63 forms, the foregoing list shows that, besides the 2 apparently new forms and perhaps the shell referred to *Mangelia linearis*, there is only one, *Tellina balthica*, which does not occur in the Crag, and also that, with the exception of this shell, not one of the 19 peculiar shells of Bridlington are among them.

The fauna of the Lower Glacial has been obtained from the thick body of pebbly sands which forms the base of, and is extensively interstratified with, the Cromer Till, and of which, in fact, the Cromer Till is itself only a local modification. The few worn and fragmentary examples which this till, and the contorted drift that overlies it, have yielded to a search so diligent that it has been carried on for years, all over Norfolk and North Suffolk, are all readily recognizable as belonging to the commoner species occurring in the pebbly sands. This fauna comprises, as the list shows, 35 forms; and though I fully expect that further search will augment the number of forms from the Middle Glacial sands, I fear, from the time which my father and myself, as well as others, have devoted to the search, that the Lower Glacial beds will not yield any considerable addition to the number of species which we have obtained. Of these 35 forms also, there is only one, the same *Tellina balthica*, which does not occur in the Crag; and, with the single exception of this shell, there is also the like absence of all the 19 forms peculiar to Bridlington that obtains in the case of the Middle Glacial.

Further, of the 63 Middle, and 35 Lower Glacial forms, 26 are common to each of these two formations, so that there remain 72 distinct forms yet obtained from the two together to set against the 70 of Bridlington. Now it is most remarkable, as the converse

of the fact of all but one of the 19 peculiar and mostly exclusively Arctic forms of Bridlington being absent from the Lower and Middle Glacial, that of these 72 forms no less than 46 do not occur at Bridlington; and even yet more striking is it that, of this 46, only 1 is exclusively Arctic.

I may add that the difference in latitude between Bridlington and these Lower and Middle Glacial shell-localities does not exceed one degree*, and that the actual distance between them and Bridlington is from 100 to 120 miles.

I defer any remarks upon the striking, Crag-like, and seemingly southern *facies* of the Middle-Glacial fauna, because I expect to add materially to the number of that fauna, and because it will be more advantageously considered when describing the structure of the Lower and Middle Glacial formations.

We see however, that, as the evidence at present stands, the fauna yet obtained from the Lower and Middle Glacial deposits (especially that from the latter) presents almost as much dissimilarity to the Bridlington fauna as the mollusca of the German Ocean do to those of the Greenland and Spitzbergen seas; so that no grounds exist for identifying, upon palæontological evidence, those Glacial beds of the Eastern Counties which are inferior to the great chalky clay, and whose structure and physical relationship to the Crag we have the advantage of studying in immediate contiguity to the Crag itself, with any of the Glacial series of Yorkshire, but, on the contrary, that the palæontological evidence points to their complete distinction. The uppermost of the East-Anglian series, the great chalky clay, with which Mr. Rome and myself identified the basement-clay of Holderness (*a*), has never yielded any other than derivative fossils; but this basement clay at Dimlington cliff, teeming with chalk (*a*), has, near to its junction with the base of the purple clay (*c*), lately yielded Sir Charles Lyell a few forms of mollusca which, he informs me, he regards, as far as they go, as resembling those of the Bridlington bed. The position of the base of Dimlington cliff, whence Sir Charles obtained these, is indicated, according to my view of the case, in the vertical section, the basement-clay from which these shells came appearing, from adjacent borings, to descend upwards of 100 feet below the base of the cliff.

I now propose to examine, on physical grounds, what part of the Yorkshire clay may, and what may not, be regarded as identical with the uppermost or great chalky member of the East-Anglian series.

The absence of chalk débris in the clay lying to the north of the Wolds seems to have been regarded by geologists as evidence of a drift from north to south, though the hypothesis never appears to have been brought to the test of critical examination until Mr. Rome and I, in our quoted paper, cursorily endeavoured to refute it. Nor do geologists ever appear to have noticed the fact, so con-

* In the case, however, of one shell, *Ostrea edulis*, obtained only at Stevenage, the difference in the latitude is nearly two degrees.

flicting with this hypothesis, that purple clay entirely destitute of chalk, but identical in most other respects with the purple clay containing chalk, extends for many miles over the extreme north-east of the Wold, ranging there from the sea-level up to altitudes of 450 feet—and that at intervals along the Holderness coast-section as far as Dimlington, and 42 miles south of the northern limit of the Wold, outliers of this purple clay without any chalk cap the purple clay with chalk that diminishes in quantity upwards.

If we merely examine the position of the clay where it lies at the Wold-foot near Speeton, more than 500 feet below the contiguous Wold-summit, without even enlisting into the argument the fact that the same clay extends over the Wold itself*, we shall, I think, perceive the impossibility of a sea-drift in any direction whatever preventing the introduction of chalk débris into it.

In the accompanying sketch map (see Plate) I have delineated, by a strong line, the exact trend of the Wold-scarp, and indicated by shading the respective positions where the clay without and that with chalk occur; and, to render the position of the clay without chalk relatively to the Wold more clear, I have added a small section (No. 2, see Plate) that will answer for the direction A to B, or A to C, indifferently.

If the Wold was uncovered by the sea (which it must have been to have supplied chalk débris), it is apparent that it must have formed a shore to any sea extending where this chalkless clay occurs, and must have arrested any drift, causing this to go off in the direction of the arrows—that is, either south-east in the direction of Flamborough, or south-west in the direction of York. Nevertheless in both these directions the clay is destitute of chalk. In the former it is so, both at high and low levels, for nearly 15 miles south-east of the northern apex of the Wolds near A, and in the latter for a much greater distance, viz. beyond York, even to the southern part of central Yorkshire†. The northern apex of the Wold rises to elevations of between 400 and 575 feet, the very highest summits (which are towards the north-west angle of the Wold), ranging between 600 and 800 feet. If we reflect what a copious source of débris this scarp-shore of chalk, indented with several valleys opening through it into the great vale beneath, must have been, and how such débris must have been swept into a sea occupying this great vale, it seems to me to be repugnant to the operation of natural causes to suppose that clay wholly destitute of chalk could be deposited in this great valley, while clay teeming with chalk was being deposited in Holderness. So obvious does this appear to me, that it is unnecessary to add to the case by appealing to the fact that the same clay without chalk envelopes both the high and low parts of the chalk Wold down nearly to Flamborough.

When we come to consider the volume and origin of the chalk

* The upper representation of the triple section (Pl. VII.) shows this.

† The clay in the vale of York is, in some parts, overlain by *Postglacial* sands, containing flint derived from the Wold. *Postglacial* gravel, with flint, also occurs in the vale of Pickering, which skirts the northern Wold-scarp.

débris that makes up so large a part of the chalky Boulder-clay, it will, I think, be apparent that had there been either a sea or a dry valley unoccupied by ice to receive it, the chalk débris, so far from being entirely absent in the clay would have been extremely abundant. None but those who have spent years in the examination of it over the greater part of the east of England can form an idea of the enormous volume of the chalk contained in the great Boulder-clay of the south-east. The proportion of this material may be estimated at from 10 to 90 per cent in different localities, the proportion being usually greatest in the counties of Norfolk, Suffolk, Essex, Hertford, and Lincoln—in the latter county, for a great distance along the western flank of the Wold, the clay being so nearly chalk itself as to be quarried for lime; and the quantity is still considerable in other counties, such as Huntingdon, Cambridge, Rutland, Leicester, Northampton, Warwick, Bedford, and Buckingham. Most of this chalk débris consists of lumps of rocky chalk of various sizes, unlike the soft material of which the upper Cretaceous formation of the south is principally composed, and so hard as to require a hammer to break it*. In these characters it is identical with the chalk of the Yorkshire Wold, which is all of this hard kind; and in it I have found, in sections where this chalky clay overlies the middle Glacial sands, rolled lumps of the red chalk which forms the base of the northern chalk, but is absent from the southern. The highest position at which the red chalk crops out in England is more than 300 feet below the higher elevations to which the chalky clay attains, and which were therefore under the sea when the red-chalk lumps, coming from a much lower level, were imbedded in its deposit.

If we consider the soluble nature of chalk, it must, as it seems to me, be evident that none of this débris can have been detached from the parent mass either by water-action or by any other atmospheric agency than moving ice.

The action of the sea, of rivers, or of the atmosphere upon chalk would take the form of dissolution, the degraded chalk being taken up in minute quantities by the water, and held in suspension by it, and in that form carried away; so that it seems obvious that this great volume of rolled chalk can have been produced in no other way than by the agency of moving ice; and for that agency to have operated to an extent adequate to produce the quantity contained in the great chalky clay before its denudation (a quantity that I estimate as exceeding a layer 200 feet thick over the entire Wold) nothing less than the complete envelopment of a large part of the Wold by ice for a long period would suffice. Nor, as it seems to me, can we explain the detachment of lumps of the red chalk from the outcrop of the parent stratum, far below the level reached by the sea that de-

* Quite different is the chalk in the Lower Glacial of Norfolk. The marl into which the contorted drift passes, and of which great masses are also imbedded in the coast, or silty development of that deposit, is a soft greasy accumulation, formed out of the soft chalk of the cretaceous districts south of the Wold.

posited the clay which contains them, in any other way than by the occupation by an ice-sheet of the great vale that extends along the scarp of the Wold where the red chalk crops out.

Another important feature bearing upon the relationship of the chalky to the chalkless clay, is the absence in the one and the presence in the other of boulders of the well-known peculiar granite of Shap Fell in Westmoreland. During the several years that I have occupied myself in examining and mapping the Glacial beds over the east of England, I have never seen such a thing as a fragment of this granite either in the various sections examined or among the numerous boulders which, exposed by atmospheric agencies, have been collected from the fields and placed by the roadside or by farmhouses &c. Neither Mr. Rome nor myself ever observed one along the Holderness coast, where the chalky clay and the purple clay with some chalk occupy the cliff; but immediately that we passed these limits and entered, about Flamborough Head, upon the region of the purple clay *without* chalk, we found them in plenty; and Mr. Rome informs me that he has seen them along the whole coast north of Flamborough, where this purple clay without chalk alone occurs, as far as the mouth of the Tees; and it is to him that I am indebted for pointing out to me (which he did more than two years since) the restriction of these boulders to the clay without chalk.

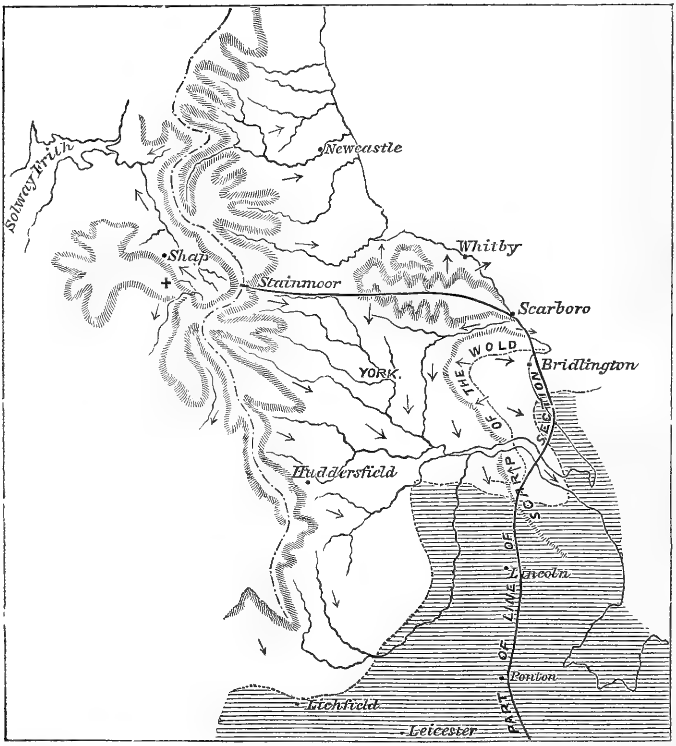
Although neither he nor myself was able to find any of these boulders along the Holderness coast, they are nevertheless said to occur as far south as the Humber mouth*; and there is no reason to suppose that such may not be the case, though rarely—because the chalky clay and the purple clay with chalk are, on this coast, capped in two or three places by outliers of the purple clay without chalk, from which these boulders might be derived.

In order to render the explanation which I offer of these facts intelligible, a small outline map of the north of England (fig. 1, p. 102) accompanies this paper, and in it are carefully shaded the slopes of the great dividing ridge of the north of England. The position of Shap Fell being on the western side of this dividing ridge, it is clear that one of two events must have occurred to enable its boulders to pass over the higher ground which separates the Shap country from the eastern side, over which the purple clay containing these boulders is distributed. The one event would be their transit by land-ice moving, not as it usually does from higher to lower ground, but upwards against the acclivity, and over the dividing ridge into the eastern area; the other would be the submergence of the country to an extent sufficient to permit the floating over of masses of ice freighted with these boulders.

With respect to the first of these alternatives, although we know that ice impelled by the force of the rearward mass of the sheet will, when this mass derives sufficient force by a descent from elevations considerably higher than the intervening obstacle, rise and pass over that obstacle—and though we may find traces of

* Quart. Journ. Geol. Soc. vol. xxiii. p. 44.

Fig. 1. *Outline Map showing the Dividing Ridge of the North of England and the distribution of ice and sea during the deposit of the chalky clay.*



The part shaded in lines represents the northern part of the area over which the chalky clay is distributed, and consequently the part regarded by the author as being sea during the deposit of that clay—the unshaded part being regarded as enveloped in ice, the sea-foot of which is indicated by the dotted line bounding the line shading. The arrows indicate the supposed direction of the ice-motion. The broken line indicates the division between the eastern and western slopes of the great ridge of the north of England. The purple clay with chalk overlaps the chalky clay up to a limit (inclusive of outliers) indicated by the dotted line on the east side of the Wold-scarp.

The + near Shap denotes the place of Wasdale Craig, where the Shap granite is *in situ*.

such a mounting, in the form of the lower elevations intervening between the Cheviots and the Northumberland coast, yet it does not appear to me that the conditions of that part of the western slope in which Shap Fell lies, offer any indications of such an upward transit*, or that the position of the dividing ridge generally would allow of the possibility of it.

We have therefore but to fall back upon the explanation of a floating-ice transit, permitted by an adequate submergence; and this explanation is strengthened by the absence of these boulders in the older or chalky part of the clay, since otherwise they ought to be present in this part equally as in the other.

Mr. Archibald Geikie, in the year 1863†, put forth his theory that the origin of the Scotch Boulder-clay was due to the extrusion, from the sea-foot of an ice-sheet enveloping the land, of the miscellaneous material which such a sheet would in its motion seaward have degraded‡. This hypothesis is that which for a long time I have entertained as the only true one of the origin of the Glacial clays of the east of England; and I venture to suggest that the application of it to the case now under consideration will not only harmonize with all the facts, both palæontological and physical, but explain that otherwise inexplicable circumstance, the positions of the purple clay without chalk, to which attention has been called.

In the same outline map I have indicated, by tint shading, that area which I regard as sea during the deposit of all but the earliest part of the chalky clay, the unshaded part having been enveloped in an ice-sheet, which barred out the sea from all those depressions which, being below its level, would otherwise have been occupied by it, just as is the case at the present day along the west coast of Greenland according to Arctic voyagers§. The same shading that indicates sea indicates also the area over which the chalky clay occurs, except that, to curtail its dimensions, the map does not extend south-

* The whole of the great basin drained by the rivers Lowther and Eden (on the side of which Shap Fell lies) is furrowed by a numerous set of small parallel ridges, with their prominences in *roches moutonnées.* These all run from S.S.E. to N.N.W., and a glance at the beautifully shaded contours of the Ordnance map shows at once, by a *coup d'œil*, that a great ice-sheet has moved *down* this basin towards the Solway shore. Similar features are afforded by the contour-shading of the slopes on the other (or eastern) side of the dividing ridge north-west of Newcastle, where the motion has been similarly outward from the dividing ridge, being there from W.S.W. to E.N.E. Mr. T. M'K. Hughes, of the Geological Survey, kindly indicated for me such striations as he had observed on the rocks of this neighbourhood; and they agree generally with the ice-motion which the map-contours indicate.

† Trans. of the Geol. Soc. of Glasgow, vol. i. part 2.

‡ The Rev. J. B. Watson too, in his memoir on the Glacial beds of Arran (Trans. Royal Soc. of Edinburgh, vol. xxiii.), adopts the same hypothesis, and adds some valuable information as to the causes in operation at the ice-foot of the Norway glaciers, derived from personal observation. The Glacial conditions of the period of the chalky clay were, however, far in excess of any thing now obtaining in Norway, and more analogous to those on the west coast of Greenland, and along the skirts of the ice-bound land of the Antarctic continent.

§ See Dr. Sutherland in Quart. Journ. Geol. Soc. vol. ix. p. 301.

wards beyond Leicester—whereas the chalky clay extends to the southern parts of Essex and Middlesex*, and the sea depositing it extended still further, as is proved by the way in which the clay is cut off from denudation at elevations reaching up to 350 feet on the northern brow of the Thames valley; but to what distance it may have gone, the denudation has been too complete in that direction to justify an assertion, though, from the structure of the Thames gravel, I believe it to have stretched beyond the limits of England.

The long triple section, No. 3, traverses the entire length of this clay from its southern termination to its overlie in Holderness by the purple clay with chalk, and thence to the purple clay without chalk, which begins about Flamborough, and, crossing one of the lowest parts of the dividing ridge at Stainmoor, terminates at the Westmoreland Fells. The upper representation of this triple section is drawn to the existing sea-level, and shows, as nearly as the small scale will allow, the relative elevations along the line taken, the older formations forming the floor of the deposit, and the distribution of the clays in question along the line taken. The Lower Glacial series (which together forms a separate and unconformable deposit) lies to the east of the line of section taken, and may be altogether omitted from consideration in this question. The Middle Glacial, although it was a deposit formed under a marine climate very different from that obtaining at the time of the chalky clay which overlies it, yet appears to have been a deposit formed during the commencement of the submergence under which the chalky clay was accumulated, since in many parts it passes up by interbedding into that clay. Features in its structure and position, which I hope to enter upon in detail on a future occasion, indicate, moreover, as it seems to me, that although the marine climate was so different from that obtaining when the chalky clay was deposited as to have permitted neither the formation of Boulder-clay† nor the transport of rock-boulders, yet the land was occupied with ice in places which were afterwards covered deep below the chalky clay, these places being far south of the ice-limit indicated in the outline map. The line of section crosses this deposit at one part only, the bulk of it lying to the east of the line, though a considerable development of it also occurs to the west of it.

The middle representation of this triple section indicates what I conceive to be the conditions obtaining when the deposit of the chalky clay was taking place. This representation supposes a depression of from 600 to 700 feet below the present level, and it shows this clay as forming southwards from the foot of the ice-sheet on the western side of the Lincolnshire Wold, and supplied by material

* The purple clay *with* chalk forms a belt in Holderness and East Lincolnshire that overlaps a little the unshaded part, and also overlies there the chalky clay which the shading represents. See sections 1, 5, and 11 of the paper of Mr. Rome and myself (Quart. Journ. Geol. Soc. vol. xxiv. pp. 148, 160, and 169.)

† A band of Boulder-clay (chalky) does occur in the Middle Glacial gravels at one or two localities, and serves as an exception to prove the truth of this rule.

extruded by that sheet and carried away by floating ice from the ice-foot during summer and distributed over the south of England, there to intermingle with material brought from other parts of the ice-foot; and it is just at the part where the section so encounters this foot, on the south-west side of the Lincolnshire Wold, that the chalky clay is in the condition of almost pure chalk and is quarried for lime. The middle representation then, after leaving the northern portion of the Lincolnshire Wold enveloped in ice, intersects the ice-foot again where the chalky, or basement, clay of Eastern Holderness (*a*) indicates that the Wold débris was also extruded. It then exhibits the Yorkshire Wold, over which the purple clay without chalk extends, as well as the great vale beneath the Wold where the same chalkless clay occurs, as entirely occupied by the ice, and the sea blocked out by it.

The lowest representation of this triple section indicates what I conceive to have been the position when the purple clay without chalk, and with Shap boulders, were deposited. This representation supposes a further depression of the land to have taken place, so as to bring it about 1500 feet below its present level, and that in consequence so much of the ice-sheet as had before enveloped the Wold, and filled the great vale below it, had been floated up and wasted away by the sea, so that only the higher elevations of the north and north-west of England, and the extreme summits of the eastern moorlands, remained enveloped in ice. This depression having also covered the lowest parts of the dividing ridge with sea and placed the Wolds many hundred feet under water, floating ice, carrying Shap boulders, was enabled to pass over the lowest parts of the dividing ridge; and thus, coincidently with the termination of all supply of chalk by the retreat of the ice-sheet from the Wold, consequent upon its deep submergence, we have the formation of a clay destitute of that material and containing Shap-boulders, which was thrown down direct on the floor of old formations over the great vale that skirts the Wold-escarpment, and generally over the north of England previously occupied by the ice.

This deposit of 1500 feet submergence is represented as extending over the purple clay with some chalk, because we can prove its extension there by outliers still remaining: but how much further it may have spread in a southerly direction I would not venture to conjecture. It may have thinned out greatly in that direction—probably it did so—so that the commencement of the denudation wrought by the sea as the land rose removed it, and with it went the Shap boulders; for it is a remarkable fact that, wherever any great area of denudation has occurred in the Boulder-clay, the various boulders of that formation have disappeared along with the clay itself.

The immense volume of the chalk débris which has been shed out to form the chalky clay appears to me to necessitate the admission that there was a long period in which the land and its enveloping ice-sheet remained stationary, at about the limits indicated in the map and in the middle representation of the triple section. I

should, however, mention that the formation of this clay must, I think, have commenced when much of the country to the south of the sea-limit, represented in the sketch map (p. 102), was uncovered by sea, because the junction of the chalky clay with the Middle Glacial sands indicates an uninterrupted succession of deposit, the change, abrupt as it is, being only in the material deposited, viz. from sand to Boulder-clay. Coupling this with the indications everywhere pointing to the circumstance that, during the Middle Glacial period, the sea does not appear to have stood more than from 400 to 450 feet above the present sea-level*, we must suppose the area of sea represented in the map, to the south of the ice-sheet, to have been considerably less at the *commencement* of the chalky-clay deposit than at the stage selected for illustration. Moreover I hope, when describing the Middle Glacial structure, to be able to show that land much below this elevation was, during the Middle Glacial deposit, occupied with ice which blocked out the sea of that formation, precisely as I have represented it (in the triple section) as doing in Yorkshire during the chalky-clay deposit. It seems to me also to follow, from the facts touched upon, that it was during this interval of pause in the subsidence, when intense cold prevailed, that the truly Arctic fauna of Bridlington, which so contrasts with that of the Middle and Lower Glacial formations, gradually became established, and that thus, the Arctic forms having become denizens of this part of England by the close of this interval, we find it in full force in the Bridlington bed†, at an horizon in the deposit which indicates a very early stage in this renewed subsidence—that is to say, in the lowest or chalky part of the purple clay. On the other hand, so far as the mollusca yet obtained afford an indication, there is ground for supposing that during the period in which the whole of that thick body of deposits forming the Cromer cliff was accumulated, and during that of the Middle Glacial sands which succeed and overlie it, no arctic mollusk, beyond such as occur in the Crag‡, except *Tellina balthica*, established itself in these parts. The introduction of *Tellina balthica* constitutes a very clear palæontological horizon, marking the commencement of the Glacial formation, which (as I hope on a future occasion to show) exactly coincides with a physical break and unconformity with the Chillesford beds and Crag that takes place at the horizon where this shell first makes its appearace; and that

* The highest point I know of at which this deposit occurs is 420 feet, which is on the north side of Rugby.

† Many of the peculiar shells of Bridlington have been found at depths equal to, and even exceeding, that supposed to have been the depth of Bridlington at the time of the setting in of the renewed submergence. It is, however, highly probable that molluscan life extends to much greater depths than we have been in the habit of supposing. The ice-foot is a favourite habitat of molluscan life (see Watson, Trans. Royal Soc. of Edin. vol. xxiii. p. 538, note); and Dr. Sutherland speaks of the extreme depths (1800 feet) at which the Esquimaux fish for halibut, whose food doubtless consists of mollusca living at those depths.

‡ One other new shell besides has been obtained from the Lower Glacial, but it seems to belong to a genus of freshwater mollusca, and is therefore omitted from the list.

break I find to be greater and more complete than I once thought. It appears also, as shown by the list before given, that during the Middle Glacial formation several Crag shells (the greater part of which are non-Arctic) of which we get no trace in the Lower Glacial returned to their former habitat. This may perhaps be due, in part (though it is far from being probable that it is so in the whole, looking at the non-Arctic character of the returned group, and the abundance of some of the shells in both the Crag and Middle Glacial), to the incompleteness of the series of mollusca obtained; but it is very significant that amongst this group of apparent returns are two shells (*Pectunculus glycimeris* and *Ostrea edulis*, neither of them Arctic) which disappeared even during the deposition of the upper beds of the Crag itself.

The recommencement of subsidence I conceive so far altered the movements of the ice that a material of which we find no trace in the great chalky clay became extruded over Holderness, viz. that reddish-brown or brownish-purple sediment in which some chalk occurs. The beds of sand and bands of blue and blackish chalky clay, alternating with bands of purple clay, which mark the junction of the purple with the great chalky clay along the Holderness coast, and which are indicated in the sections of Mr. Rome and myself as well as in the accompanying vertical section by the letter *b*, seem to me to indicate the termination of this long stationary interval, or pause in the subsidence during which the great volume of chalk was shed out, and the setting in of the renewed depression, the first result of which was the limited deposit of purple clay, wherein the chalk débris, tolerably abundant at first, rapidly diminishes in quantity upwards, and the eventual result the passing over of the Shap boulders and deposit of the purple clay without any chalk.

The transition from a depression of 600 or 700 feet to one of 1500 and upwards would, we may infer, produce a great change in the conditions under which the mollusca existed. Our ideas about the depths which mollusca inhabit are undergoing much change from the dredging expeditions, and our knowledge on the subject is too defective at present to justify any conjectures as to what results might in this respect be expected to ensue on the purple-clay submergence. Our knowledge, moreover, of the mollusca of the purple clay without chalk is very restricted. Mr. Leckenby enumerates* ten species as obtained by himself and Mr. Jeffreys from the Glacial beds of the cliff about Scarborough and Whitby, which belong to the purple clay without chalk and with Shap boulders and with gravel intercalations (c' and $\bar{c}$ of the vertical section). The species so enumerated are as follows:—*Cardium edule*, *Mytilus edulis*, *Cyprina islandica*, *Venus lincta*, *Astarte borealis*, *Astarte sulcata*, var. *elliptica*, *Tellina lata*, *Tellina balthica*, *Mya truncata*, var. *uddevallensis*, and *Pholas crispata*.

These are too few in number to afford any reliable comparison with the Bridlington fauna; but, as far as they go, they agree satisfactorily with the newer age of the purple clay without chalk

* Geol. Mag. vol. ii. p. 348.

which I have been deducing from physical evidence; for though we do not find any one of the peculiar shells of Bridlington amongst them, all of them belong to existing forms, and one, the *uddevallensis* variety of *Mya truncata*, is unknown either to the Crag, to the Lower, or to the Middle Glacial, and is also unknown at Bridlington, while it occurs in the yet newer beds of the Clyde, and is still living.

Very unlike the Bridlington fauna also is that of Moel Tryfaen, given in detail by Mr. Darbishire*. The list from that place is moreover equally unlike that of the shells from the Middle and Lower Glacial and from the Crag. The Moel-Tryfaen fauna, however, must have lived when this country was depressed nearly as much below the present sea-level as it was when the Shap boulders came over into the purple clay; but we must recollect that equal degrees of depression do not necessarily, even if the movement were uniform, imply an identity in age between deposits accumulated under them, since the one deposit may have been formed when the land was going down, and the other when it was rising, and the two be thus separated by a not inconsiderable interval of time, during which material changes in temperature may have occurred. The Moel-Tryfaen bed therefore, instead of being synchronous with the purple clay without chalk, may not improbably belong to the epoch of emergence—that is to say, to the very earliest part of the Post-glacial period, that, in fact, to which Mr. A. Geikie refers the stratified drift of Scotland.

The prevalence of high land throughout Scotland, coupled with its higher latitude, concur to suggest that the ice-sheet would cling to that country after the far less elevated and more southern districts of the east and east centre of England had become freed from it; and the belief is therefore strong with me that the Glacial beds of Scotland belong, if not wholly, yet in greater part, to such later deposits as the north-of-England Glacial clay. One remarkable exception, however, exists to this, in the Aberdeenshire bed described by Mr. Jamieson in the 16th vol. of the Society's Journal (p. 347), which, both in its physical structure and organic contents, seems to agree with the Middle Glacial formation of England.

Note.—Since this paper was sent in with the lower representation of the triple section drawn to such a supposed submergence (1500 feet) as would cover Stainmoor Pass with sea, I have been enabled, by the kind assistance of Mr. Thos. M'K. Hughes (who is engaged on the geological survey of the district), to point out what other routes than that of Stainmoor Pass exist by which floating ice bearing Shap boulders could, so far as elevation is concerned, have passed the dividing ridge under such a submergence as represented. These routes are as follows:—

1. Up the valley of the Eden, and so over into the valley of the Ure, and thence into Wensleydale.

* Geol. Mag. vol. ii. p. 298.

2. Down the valley of the Lune to Sedbergh, thence up the valley of the Rawthey, or up that of the Clough, and so over into the valley of the Ure.
3. From Sedbergh up the valley of the Dee, and so over into the valley of the Widdale beck. and thence into Wensleydale.
4. Down the valley of the Lune to below Kirkby Lonsdale, thence up the valley of the Greta and that of the Dale beck, over into the valley of the Gale beck, and thence over again into the valley of the Widdale beck.
5. From the Gale beck up the Cam beck, and so over into Wharfedale.
6. From the valley of the Greta (as in No. 4) up that of the Wenning, and thence either by the valley of the Anstwick beck, or that of the Fen beck, over into the valley of the Ribble, and thence over again into the valleys of various becks that are tributary to the Aire.

In the first and second of these routes, the highest ground required to be covered by the sea seems about 1200 feet, in the third and fourth it seems about 1500 feet, in the fifth between 1200 and 1300 feet, but in the sixth there seems to be no barrier above 800 feet, while Stainmoor Pass is 1400 feet above the sea-level. The height of the top of Wasdale Craig (the original source of the boulders, according to Prof. Phillips) is marked on the Ordnance map as 1479 feet.

The lowest of these several elevations would accord with the phenomena discussed in this paper, since it would place the chalk Wold below the sea-level. I conceive, however, that a considerable depth of sea-water would be necessary to waste the ice out of the valleys along the transit route previously occupied by the ice-sheet; and until this was effected a floating transit could not take place; but it is remarkable that, according to those who have studied the distribution of the Shap boulders, they do not seem to occur in Airedale, along which dale the route requiring the least submergence passes, and that it is by the more elevated route of Stainmoor that most of these boulders have come into the east of Yorkshire. These apparently conflicting phenomena, and similar phenomena attending the non-transit of the blocks over the watershed between the Lune and the Kent, referred to by Prof. Phillips*, appear to me susceptible of a satisfactory explanation by supposing the lower routes to have continued blocked by ice after a higher route by which the blocks have passed, such as Stainmoor, had become free from it, and so remained until the source of the blocks had become submerged†. If that explanation be the true one, it would seem to follow that, during the Postglacial emergence, no ice existed in these parts adequate to the transport ef the blocks until after the lowest of these routes had reached the surface otherwise we should expect their transit by the lower routes to have occurred

* See Report of Brit. Assoc. for 1864, p. 65. The Professor argues that the *relative* elevations of the country around Wasdale Craig must have greatly altered since the diffusion of the blocks, in order to reconcile the places of their occurrence.

† The depth at which ice floats would enable it to pick up blocks even after the parent source of them had become submerged; and these, by the many turnings over and squeezings up which occur to floating ice, might become transferred to ice of so much less draught of water that they could pass even higher elevations than the original source.

at that time. Later than this, considerably, however, and when far larger tracts had become established as land, we get from the Hessle clay evidence that ice adequate to the transport of blocks of 2 or 3 cubic feet in dimensions was in existence, though such blocks are but very rare in it.

Discussion.

Mr. Gwyn Jeffreys had found the shells of Kelsea and elsewhere in Yorkshire to be mainly arctic, and Mr. Prestwich, in his paper on the Boulder-clay near Hull, had first pointed out their glacial character. In the late dredgings in H.M.S. 'Porcupine' several of the species before known as fossil at Bridlington, but not as existing in the British seas, had been discovered. In fact he believed that the Bridlington species, with but few exceptions, had now been found in the British seas. Similar species had also been found in the Boulder-clay in Scotland.

Prof. Ramsay was pleased to find the author's views so closely correspond with his own published some years ago as to the glacial phenomena of North Wales, though based on another part of the country. He thought that shells might be found by careful search in the low-lying Boulder-clay in other places than those enumerated, as they had been discovered in the western part of England.

Mr. Prestwich, though inclined to accept the divisions of the Boulder-clay in Yorkshire as suggested by the author, was not so clear as to his divisions in the south. He thought the presence of chalk in the clay might be traced to the contiguity of the outcrop of the chalk stratum. The shells being to a very great extent recent, the grouping might be due to accidental or local circumstances. The Chillesford clays, in his opinion, marked the commencement of the great Glacial period.

Mr. Etheridge suggested that *Nucula Cobboldiæ*, *Cardita similis*, and some other shells not found in the British seas, proved the arctic character of the Bridlington fauna.

Sir Charles Lyell remarked that if the fauna of the Lower and Middle Glacial really corresponded so closely with that of the Crag, it afforded a strong argument against their being of the same age as the Bridlington beds. Perhaps eventually some palæontological connexion might be traced throughout the series, and a chronological scale established.

The President suggested a difficulty in the marine transport of ice from Shap Fell to Bridlington, not only from the wind blowing rarely in the necessary direction, but from the current caused by the great submerged ridge also tending to carry any bergs in another direction. He thought the transport by sheet-ice more probable.

The Rev. J. L. Rome had traced the Shap granites over the valley of the Eden, across Stainmoor to the Yorkshire side. There might have been difficulties in their transport, but there they are. Though they were found in Teesdale, yet the intervening ridge of millstone-grit, 2000 feet, had prevented their finding their way into Swale Dale.

Mr. Searles V. Wood, Jun., stated that he had relied on Mr. Gwyn Jeffreys's works for his classification of the shells as being arctic or otherwise. He regarded the succession of the various members of the Glacial series of the eastern side of England as well founded, and borne out also by the molluscan remains. He utterly repudiated the notion that the Chillesford, Bridlington, and Kelsea-Hill beds were on the same horizon. He believed nearly the whole of the Scotch beds to be newer than those of the Middle and Lower Glacial. He quoted Prof. Phillips as suggesting a change in the relative elevations around Shap Fell since the dispersion of the boulders, and offered as his own explanation the hypothesis that the passes by which the boulders travelled were those which, though at the higher levels, were the soonest freed from ice. He thought that the direction of the current was influenced by other causes than the general trend of the rocky dividing ridge.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

POSTPONED PAPERS.

1. *On the* Graphite *of the* Laurentian *of* Canada. By J. W. Dawson, LL.D., F.R.S., F.G.S.

(Read June 23, 1869 *.)

In my paper of 1864, on the Organic Remains of the Laurentian Limestones of Canada, as a sequel to the description of *Eozoon Canadense*, I noticed, among other indications of organic matters in these limestones, the presence of films and fibres of graphitic matter, and insisted on the probability that at least some of the lower forms of plant life must have existed in the seas in which gigantic Foraminifera could flourish. Dr. Hunt had previously, on chemical evidence, inferred the existence of Laurentian vegetation †, and Dana had argued as to the probability of this on various grounds ‡; and my object in referring to these indications in 1864, as well as to the supposed burrows of annelids, subsequently described by me §, was to show that the occurrence of *Eozoon* was not to be regarded as altogether isolated and unsupported by probabilities of the existence of organic remains in the Laurentian deducible from other considerations.

Now that the questions which have been raised regarding *Eozoon*

* For the Discussion on this paper see p. 406 of the last volume of the Journal.

† 'American Journal of Science' (2), xxxi. p. 395. From this article, written in 1861, after the announcement of the existence of laminated forms supposed to be organic in the Laurentian, by Sir W. E. Logan, but before their structure and affinities had been ascertained, I quote the following sentences:—"We see in the Laurentian series beds and veins of metallic sulphurets, precisely as in more recent formations; and the extensive beds of iron-ore, hundreds of feet thick, which abound in that ancient system, correspond not only to great volumes of strata deprived of that metal, but, as we may suppose, to organic matters which, but for the then great diffusion of iron-oxyd in conditions favourable for their oxydation, might have formed deposits of mineral carbon far more extensive than those beds of plumbago which we actually meet in the Laurentian strata. All these conditions lead us then to conclude the existence of an abundant vegetation during the Laurentian period."

‡ Manual of Geology. I may also be permitted to refer to my own work 'Archaia,' p. 168, and Appendix D, 1860.

§ Quart. Journ. Geol. Soc. vol. xxii. p. 608.

may be considered settled, not only by the adhesion of the greatest authorities in palæontology and zoology, but by the discovery of similar organisms in rocks of the same age elsewhere, by specimens preserved in such a manner as to avoid all the objections raised to the mineral condition of the fossil*, and by the discovery of such modern analogies as that furnished by *Bathybius,* it may be proper to invite the attention of geologists more particularly to the evidence of vegetable life afforded by the deposits of graphite existing in the Laurentian.

The graphite of the Laurentian of Canada occurs both in beds and in veins, and in such a manner as to show that its origin and deposition are contemporaneous with those of the containing rock. Sir William Logan states† that "the deposits of plumbago generally occur in the limestones or in their immediate vicinity, and granular varieties of the rock often contain large crystalline plates of plumbago. At other times this mineral is so finely disseminated as to give a bluish-gray colour to the limestone, and the distribution of bands thus coloured, seems to mark the stratification of the rock." He further states:—"The plumbago is not confined to the limestones; large crystalline scales of it are occasionally disseminated in pyroxene rock or pyrallolite, and sometimes in quartzite and in feldspathic rocks, or even in magnetic oxide of iron." In addition to these bedded forms, there are also true veins in which graphite occurs associated with calcite, quartz, orthoclase, or pyroxene, and either in disseminated scales, in detached masses, or in bands or layers "separated from each other, and from the wall rock by feldspar, pyroxene, and quartz." Dr. Hunt also mentions the occurrence of finely granular varieties, and of that peculiarly waved and corrugated variety simulating fossil wood, though really a mere form of laminated structure, which also occurs at Warrensburgh, New York, and at the Marinski mine in Siberia. Many of the veins are not true fissures, but rather constitute a net-work of shrinkage cracks or segregation veins traversing in countless numbers the containing rock, and most irregular in their dimensions, so that they often resemble strings of nodular masses. It has been supposed that the graphite of the veins was originally introduced as a liquid hydro-carbon. Dr. Hunt, however, regards it as possible that it may have been in a state of aqueous solution‡; but in whatever way introduced, the character of the veins indicates that in the case of the greater number of them the carbonaceous material must have been derived from the bedded rocks traversed by these veins, while there can be no doubt that the graphite found in the beds has

* I cannot, after examination of the specimen, and of others subsequently obtained by Sir W. E. Logan, attach any value to the supposition of Messrs. Rowney & King that the Tudor specimen has been produced by infiltration of carbonate of lime into veins. The mechanical arrangement of the laminæ and their microscopic structure forbid such a supposition, as well as the comparison of them with actual calcareous veins occurring in the same rock.

† 'Geology of Canada,' 1863.

‡ 'Report of the Geological Survey of Canada,' 1866.

been deposited along with the calcareous matter or muddy and sandy sediment of which these beds were originally composed.

The quantity of graphite in the Lower Laurentian series is enormous. In a recent visit to the township of Buckingham, on the Ottawa River, I examined a band of limestone believed to be a continuation of that described by Sir W. E. Logan as the Green Lake Limestone. It was estimated to amount, with some thin interstratified bands of gneiss, to a thickness of 600 feet or more, and was found to be filled with disseminated crystals of graphite and veins of the mineral to such an extent as to constitute in some places one-fourth of the whole; and making every allowance for the poorer portions, this band cannot contain in all a less vertical thickness of pure graphite than from 20 to 30 feet. In the adjoining township of Lochaber Sir W. E. Logan notices a band from 25 to 30 feet thick, reticulated with graphite veins to such an extent as to be mined with profit for the mineral. At another place in the same district a bed of graphite from 10 to 12 feet thick, and yielding 20 per cent. of the pure material, is worked. When it is considered that graphite occurs in similar abundance at several other horizons, in beds of limestone which have been ascertained by Sir W. E. Logan to have an aggregate thickness of 3500 feet, it is scarcely an exaggeration to maintain that the quantity of carbon in the Laurentian is equal to that in similar areas of the Carboniferous System. It is also to be observed that an immense area in Canada appears to be occupied by these graphitic and *Eozoon*-limestones, and that rich graphitic deposits exist in the continuation of this system in the State of New York, while in rocks believed to be of this age near St. John, New Brunswick, there is a very thick bed of graphitic limestone, and associated with it three regular beds of graphite, having an aggregate thickness of about 5 feet*.

It may fairly be assumed that in the present world and in those geological periods with whose organic remains we are more familiar than with those of the Laurentian, there is no other source of unoxidized carbon in rocks than that furnished by organic matter, and that this has obtained its carbon in all cases, in the first instance, from the deoxidation of carbonic acid by living plants. No other source of carbon can, I believe, be imagined in the Laurentian period. We may, however, suppose either that the graphitic matter of the Laurentian has been accumulated in beds like those of coal, or that it has consisted of diffused bituminous matter similar to that in more modern bituminous shales and bituminous and oil-bearing limestones. The beds of graphite near St. John, some of those in the gneiss at Ticonderoga in New York, and at Lochaber and Buckingham and elsewhere in Canada are so pure and regular that one might fairly compare them with the graphitic coal of Rhode Island. These instances, however, are exceptional, and the greater part of the disseminated and vein graphite might rather be compared in its

* Matthew in 'Quart. Journ. Geol. Soc.' vol. xxi. p. 423. Acadian Geology, p. 662.

mode of occurrence to the bituminous matter in bituminous shales and limestones.

We may compare the disseminated graphite to that which we find in those districts of Canada in which Silurian and Devonian bituminous shales and limestones have been metamorphosed and converted into graphitic rocks not dissimilar to those in the less altered portions of the Laurentian*. In like manner it seems probable that the numerous reticulating veins of graphite may have been formed by the segregation of bituminous matter into fissures and planes of least resistance, in the manner in which such veins occur in modern bituminous limestones and shales. Such bituminous veins occur in the Lower Carboniferous limestone and shale of Dorchester and Hillsborough, New Brunswick, with an arrangement very similar to that of the veins of graphite; and in the Quebec rocks of Point Levi, veins attaining to a thickness of more than a foot, are filled with a coaly matter having a transverse columnar structure and regarded by Logan and Hunt as an altered bitumen. These palæozoic analogies would lead us to infer that the larger part of the Laurentian graphite falls under the second class of deposits above mentioned, and that, if of vegetable origin, the organic matter must have been thoroughly disintegrated and bituminized before it was changed into graphite. This would also give a probability that the vegetation implied was aquatic, or at least that it was accumulated under water.

Dr. Hunt has, however, observed an indication of terrestrial vegetation, or at least of subaerial decay, in the great beds of Laurentian iron-ore. These, if formed in the same manner as more modern deposits of this kind, would imply the reducing and solvent action of substances produced in the decay of plants. In this case such great ore beds as that of Hull, on the Ottawa, 70 feet thick, or that near Newborough, 200 feet thick†, must represent a corresponding quantity of vegetable matter which has totally disappeared. It may be added that similar demands on vegetable matter as a deoxidizing agent are made by the beds and veins of metallic sulphides of the Laurentian, though some of the latter are no doubt of later date than the Laurentian rocks themselves.

It would be very desirable to confirm such conclusions as those above deduced by the evidence of actual microscopic structure. It is to be observed, however, that when, in more modern sediments, Algæ have been converted into bituminous matter, we cannot ordinarily obtain any structural evidence of the origin of such bitumen, and in the graphitic slates and limestones derived from the metamorphosis of such rocks no organic structure remains. It is true that, in certain bituminous shales and limestones of the Silurian system, shreds of organic tissue can sometimes be detected, and in some cases, as in the Lower Silurian limestone of the La Cloche mountains in Canada, the pores of brachiopodous shells and the cells of corals have been penetrated by black bituminous matter, forming

* Granby, Melbourne, Owl's Head, &c., 'Geology of Canada,' 1863, p. 599.
† Geology of Canada, 1863.

what may be regarded as natural injections, sometimes of much beauty. In correspondence with this, while in some Laurentian graphitic rocks, as, for instance, in the compact graphite of Clarendon, the carbon presents a curdled appearance due to segregation, and precisely similar to that of the bitumen in more modern bituminous rocks, I can detect in the graphitic limestones occasional fibrous structures which may be remains of plants, and in some specimens vermicular lines, which I believe to be tubes of *Eozoon* penetrated by matter once bituminous, but now in the state of graphite.

When palæozoic land-plants have been converted into graphite, they sometimes perfectly retain their structure. Mineral charcoal, with structure, exists in the graphitic coal of Rhode Island. The fronds of ferns, with their minutest veins perfect, are preserved in the Devonian shales of St. John, in the state of graphite; and in the same formation there are trunks of Conifers (*Dadoxylon onangondianum*) in which the material of the cell-walls has been converted into graphite, while their cavities have been filled with calcareous spar and quartz, the finest structures being preserved quite as well as in comparatively unaltered specimens from the coal-formation*. No structures so perfect have as yet been detected in the Laurentian, though in the largest of the three graphitic beds at St. John there appear to be fibrous structures, which I believe may indicate the existence of land-plants. This graphite is composed of contorted and slickensided laminæ, much like those of some bituminous shales and coarse coals; and in these there are occasional small pyritous masses which show hollow carbonaceous fibres, in some cases presenting obscure indications of lateral pores. I regard these indications, however, as uncertain; and it is not as yet fully ascertained that these beds at St. John are on the same geological horizon with the Lower Laurentian of Canada, though they certainly underlie the Primordial series of the Acadian group, and are separated from it by beds having the character of the Huronian.

There is thus no absolute impossibility that distinct organic tissues may be found in the Laurentian graphite, if formed from land-plants, more especially if any plants existed at that time having true woody or vascular tissues; but it cannot with certainty be affirmed that such tissues have been found. It is possible, however, that in the Laurentian period the vegetation of the land may have consisted wholly of cellular plants, as, for example, mosses and lichens; and if so, there would be comparatively little hope of the distinct preservation of their forms or tissues, or of our being able to distinguish the remains of land-plants from those of Algæ.

We may sum up these facts and considerations in the following statements:—First, that somewhat obscure traces of organic structure can be detected in the Laurentian graphite; secondly, that the general arrangement and microscopic structure of the substance corresponds with that of the carbonaceous and bituminous matters in

* Acadian Geology, p. 535. In calcified specimens the structures remain in the graphite after decalcification by an acid.

marine formations of more modern date; thirdly, that if the Laurentian graphite has been derived from vegetable matter, it has only undergone a metamorphosis similar in kind to that which organic matter in metamorphosed sediment of later age has experienced; fourthly, that the association of the graphitic matter with organic limestone, beds of iron ore, and metallic sulphides greatly strengthens the probability of its vegetable origin; fifthly, that when we consider the immense thickness and extent of the Eozoonal and graphitic limestones and iron-ore deposits of the Laurentian, if we admit the organic origin of the limestone and graphite, we must be prepared to believe that the life of that early period, though it may have existed under low forms, was most copiously developed, and that it equalled, perhaps surpassed, in its results, in the way of geological accumulation, that of any subsequent period.

In conclusion, this subject opens up several interesting fields of chemical, physiological, and geological inquiry. One of these relates to the conclusions stated by Dr. Hunt as to the probable existence of a large amount of carbonic acid in the Laurentian atmosphere, and of much carbonate of lime in the seas of that period, and the possible relation of this to the abundance of certain low forms of plants and animals. Another is the comparison already instituted by Professor Huxley and Dr. Carpenter, between the conditions of the Laurentian and those of the deeper parts of the modern ocean. Another is the possible occurrence of other forms of animal life than *Eozoon* and Annelids, which I have stated in my paper of 1864, after extensive microscopic study of the Laurentian limestones, to be indicated by the occurrence of calcareous fragments, differing in structure from *Eozoon*, but at present of unknown nature. Another is the effort to bridge over, by further discoveries similar to that of the *Eozoon bavaricum* of Gümbel, the gap now existing between the life of the Lower-Laurentian and that of the Primordial Silurian or Cambrian period. It is scarcely too much to say that these inquiries open up a new world of thought and investigation, and hold out the hope of bringing us into the presence of the actual origin of organic life on our planet, though this may perhaps be found to have been Prelaurentian. I would here take the opportunity of stating that, in proposing the name *Eozoon* for the first fossil of the Laurentian, and in suggesting for the period the name "Eozoic," I have by no means desired to exclude the possibility of forms of life which may have been precursors of what is now to us the dawn of organic existence. Should remains of still older organisms be found in those rocks now known to us only by pebbles in the Laurentian, these names will at least serve to mark an important stage in geological investigation.

2. *A few* Remarks *on the* Geology *of the* Country *surrounding the* Gulf of Cambay, *in* Western India. By Alex. Rogers, Bombay Civil Service.

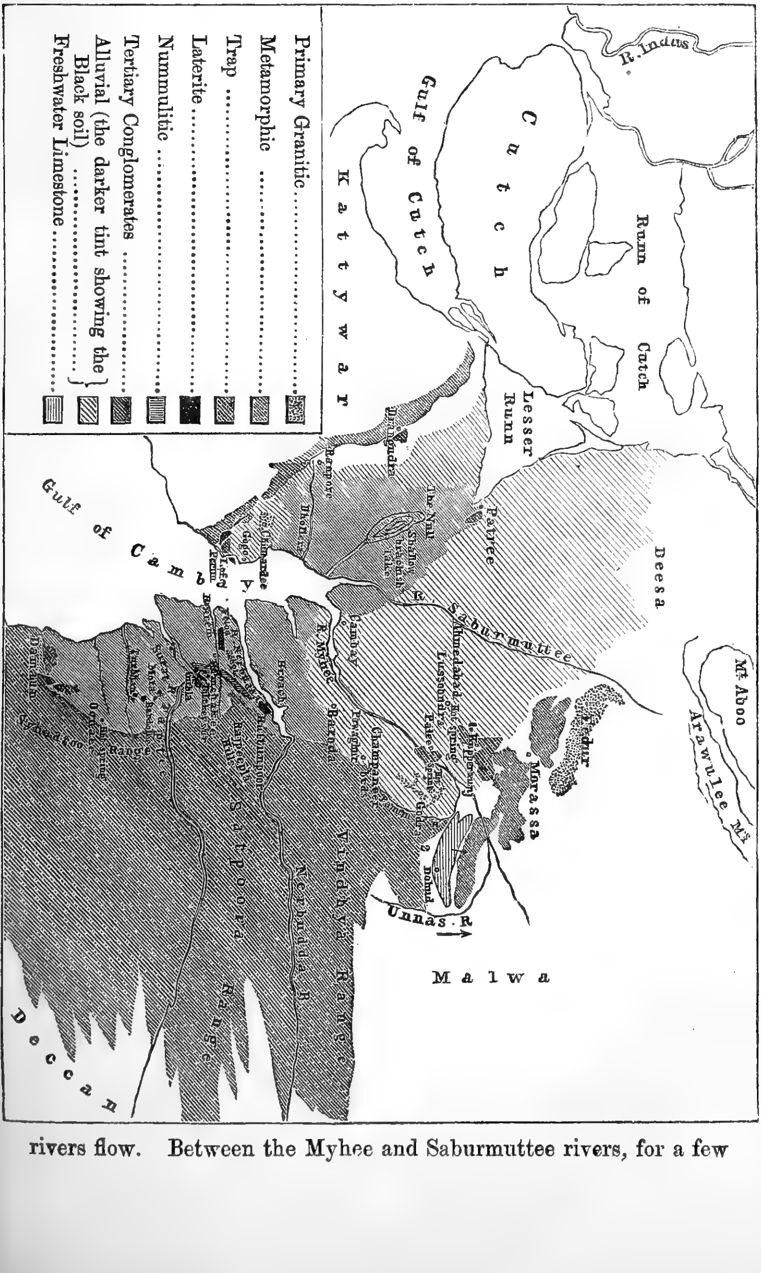
(Read June 23, 1869*.)

The rapid silting up of the Gulf of Cambay gives particular interest to an inquiry into the geological conditions which probably shaped it in remote ages, and the gradual changes which have modified its original form, and brought it to its present state. The geological features of the country surrounding the Gulf afford, when taken as a whole, an unusually clear clue to the nature of some of these changes, and may assist us in tracing what may have taken place in the region between the head of the Gulf and the present mouths of the Indus, and in the desert between Rajpootana and Sind. The former comprises within itself the Great Runn of Cutch, which has already received much attention from the most distinguished geologists. It will be seen, from the accompanying rough geological map of the Gulf and its neighbourhood (fig. 1), that primary or metamorphic rocks are traceable in its immediate vicinity only in a small tract on its west coast. Here they appear in isolated peaks of from a few to two or three hundred feet in height above the alluvium that surrounds them near Chumardee, but are also found on and below the general level of the country for about fifty miles to the north and north-west of that village. They also appear on the east of the river Myhee to the north and north-west of the hill of Powaghur in a precisely similar position with reference to the surrounding country to those on the west of the Gulf. In both these localities even the highest points of the granite peaks show signs of weathering, and probably also of the erosive action of waves. The same effects being visible down to the present level of the country, and detritus derived from the long-continued denudation of the higher rocks having in some cases accumulated round their base to a considerable depth, prove that the raising of the level of the land, the cause of the granitic rocks now appearing as islands in a sea of alluvium, must have occupied immense periods of time. Granitic and metamorphic rocks appear in regular ranges, and extending over large tracts of country, for the first time fifty or sixty miles north-east of Ahmedabad, or fully a hundred miles from the head of the Gulf, running in an easterly and north-easterly direction. Between these and the desert that lies between Rajpootana and Sind to the north-west, and as far as Cutch and Kattywar on the west and south-west, there is not a rock to be found; all is deep alluvium, of consistencies varying from that of almost pure siliceous sand to that of the rich light-coloured "Goraroo" soil of Goozerat (which may in some places be cut almost as butter may with a knife), and the deep black "Regur" or cotton soil. Through this alluvium the Saburmuttee and other rivers cut their way, frequently exposing sections of 20 feet or 30 feet in depth without a trace of stone *in*

* For the Discussion on this paper see p. 441 of the last volume of the Journal.

situ, and hardly even containing gravel. It is worthy of note that no really black soil occurs in all the region through which these

Fig. 1. *Map of the country surrounding the Gulf of Cambay.*



rivers flow. Between the Myhee and Saburmuttee rivers, for a few

miles to the south and south-east of the former near its mouth, and on the west bank of the latter to about halfway between Ahmedabad and the head of the Gulf, the soil is all light-coloured, containing particles mostly derived from the primary and metamorphic rocks to the north-east. The black soil lies in one extensive bed to the west of the last-mentioned limit of the light-coloured soil, widening out on both sides towards the mouth of the Saburmuttee, and down the west coast of the Gulf, but becoming lighter after it reaches the granitic region. This westerly belt stretches beyond the head of the Gulf as far at least as the Lesser Runn, and probably impinges on the Great Runn itself. The alluvial soil to the north of Baroda, between the Myhee and the trap range running to the north-east from Powaghur, beyond the Champaneer beds mentioned by Mr. Blanford, is of a general character between those of the light-coloured and black varieties; and the deltas between the mouths of the Myhee, the Nerbudda, the Taptee, and a point about fifty miles to the south of Surat, where the trap touches the present coast-line, are again all black.

We have now to consider whence these enormous alluvial deposits can have been derived. With regard to those on the east coast of the Gulf of Cambay, there can be no hesitation in ascribing them to the gradual action of the two large rivers Nerbudda and Taptee, and the numerous smaller streams which flow from the east, either from the western range of Ghauts or passing through gorges in that range from further east. There is no doubt that the washings of the trap-rocks which compose that range enter largely into the composition of the black soil which, as already stated, occupies almost the whole of the east coast of the Gulf; for much of the trap is amygdaloidal, and zeolitic minerals derived from it are found in abundance in the soil. But this cannot be said of the light-coloured soil on the north-east of the Gulf, which must be chiefly derived from the primary and metamorphic rocks in that direction mentioned above—or of the black belt running from the head of the Gulf in a north-westerly direction, in which there are no rock formations at all to account for the colour of the soil. It is as well to notice here that the fact of this belt being just of as dark a colour as that lying on the east coast apparently militates against the theory that this colour is derived from the presence of iron in the trap-rocks from which it is believed to be formed. The Myhee, the Saburmuttee, and other streams which now fall into the Gulf at its northern extremity are not sufficiently large to account for the deposit, especially for the belt of black soil to the north-west, extending as far as the Lesser Runn. Many considerations point to the existence in former ages of some large river flowing down from the north, and falling into the Indian Ocean somewhere in the position of the present Gulf of Cambay; and it is not improbable that that river may have been the Indus. It may have been that the original course of the Indus from the Punjaub was in a more south-easterly direction than that of the present day; or it may from the first have had several mouths, some in the position of its existing delta, others

further eastward, in the position of the Greater and Lesser Runns, to the west and east of Cutch, and again in that of the country between the Lesser Runn and the Gulf of Cambay. In this last-mentioned tract of country, coinciding to a great extent with the black-soil belt, there can be clearly traced a natural depression in the surface of the country for some twenty miles from the head of the Gulf, terminating in a shallow lake of brackish water called the Null. This lake, in the rainy season, is probably twenty miles long and three or four broad, and finds an outlet for its superfluous waters at that season through the Bhogava, which enters the Gulf at its north-west corner. Shells of the genus *Cerithium*, an estuarine form, are found lying loose in the black soil many miles from this point; and the records of the old Revenue Survey of Goozerat state that there were formerly found in the Null large round stones with holes through them, which had evidently served as anchors for boats of some size. In all this we have strong presumptive evidence of a connexion between the Gulf of Cambay and the Runns at a comparatively modern period; and there is historical and well-known proof of the alteration of the level of the larger of these salt flats as the consequence of an earthquake in A.D. 1819. May we not, then, imagine a time before the great trap effusions of Western India had been poured out, when the granite rocks on the west and north-east of the Gulf were wave-beaten islets surrounded by the Indian Ocean, which then probably covered the whole region up to the Cretaceous formations of Central India, at the mouth or one of the mouths of the Indus or some corresponding great river? In a report lately made by Mr. Blanford, of the Geological Survey of India, the age of the great trap formation of the Deccan and Malwa, of which that lying on the east of the Gulf of Cambay forms a part, has been determined to be between the Cretaceous and the Lower Eocene. This conclusion has been come to mainly from an examination of the Nummulitic formation between the Taptee and Nerbudda rivers. Mr. Blanford has also shown, from an examination of these traps and the intertrappean formations of Bombay and other places, that there have been not one but many successive eruptions and accumulations, probably extending over long periods. May it not, then, have been that previously to any of these the Indus had, if not its sole, at least its most easterly mouth in the Gulf of Cambay? that on the upheaval of the trap the tract to the west and south-west of the primary and metamorphic rocks to the north-east of the gulf was raised, and has since risen gradually so as to throw the course of the river more and more to the westward, drying up successively its channels of communication with the Gulf of Cambay and the Lesser and Greater Runns until it attained its present course and exit into the Indian Ocean near Kurrachee? If there is truth in the theory that rivers running towards the equator from the north and south have a tendency, in consequence of the earth's diurnal motion, to wear away their western banks, this may have assisted the westward motion of the river. Before the final upheaval of trap on the north-east of

the gulf, moreover, it is probable that the drainage of the country to the west of Malwa found its way to the ocean in a south-westerly direction, and that that upheaval diverted it to the north, as seen by the course of the two principal tributaries of the Myhee, the Panum and Unnas, which join that river before it takes its final bend to the south-west. The original slope of the country in that direction from the time at which it began to assume its present general configuration, may be inferred from the position of the granitic and other formations mentioned. The northerly course of these two tributaries of the Myhee, the tilting up in the same direction of the metamorphic rocks to the north of Dohud, and the existence of a large freshwater limestone formation in the same neighbourhood, in the country between the trap and metamorphic rocks, point to the sudden diversion of the drainage of the tract to the west of Malwa towards the north, and the formation of large freshwater lakes. The existence of these is proved by specimens containing *Bithynia*, *Paludina*, and probably imperfect remains of *Physa*, possibly of the same age as those from Nagpore collected by the late Mr. Hislop. This formation, however, has only been very cursorily examined by me in the course of hurried official visits, and may yet yield far better specimens than those now before me.

As soon as the gulf assumed somewhat of its present form, the access of water to it from the north-west having become cut off, the process by which it is now being rapidly silted up must have commenced. This has been of a twofold nature, namely, the bringing down of alluvium by the Saburmuttee, the Myhee, the Nerbudda, the Taptee, and other smaller rivers, and the deposit of silt by the action of the tide. The gulf being somewhat funnel-shaped, the bore runs up it with considerable force, leaving behind it as the tide glides down again towards the ocean a deposit clearly visible to the naked eye. When this silting first commenced at the head of the gulf the rivers flowing into it from the east could not have had sufficient time to bring down the enormous amount of alluvial deposit now found along that coast, and mostly derived from the denudation of the traps. The Nummulitic and more recent formations between the Nerbudda and Taptee, and on the opposite coast, near Gogo, with which the Island of Perim was probably connected at no very distant date, would thus have found time to accumulate. As the silting process extended, the limits of the sea would be thrown further back, the older rocks on the west and north-east of the gulf would be the first enveloped in the silt, and finally the Nummulitic and more recent formations would be left high and dry as the silt encroached upon and narrowed the gulf. We should then be approaching the time of man's appearance on earth; and recent discoveries of stone implements in India, especially those in the Madras Presidency by Mr. Foote, have rendered the minute examination of the geology of that period in Western India of great importance. The formation in which Mr. Foote has found these objects is said to be laterite, which he is of opinion must have been deposited in a shallow sea. Interesting questions, therefore, at once arise as to whether that

laterite is the same in age and composition as the laterite of western India. Their difference has already been pointed out by Newbold and Aytoun; and that in Madras may be presumed, for the following reasons, to be of a much later date than that of Bombay, probably only a lateritic or ferruginous conglomerate. The laterite of Bombay overlies the great trap formation at all elevations of from less than a hundred feet above the level of the sea in the country round the Gulf of Cambay to 5000 or 6000 feet above it on the highest Ghaut-level. In connexion with the Turkeysur nummulitic rocks, Mr. Wynne, in his Report on the Geology of the Surat Collectorate, speaks as follows:—

"A low range of hills rises near this town and stretches southwards towards the Taptee; they are formed of ferruginous or lateritic beds intercalated between agate conglomerates, and, having a low dip to the west, they pass beneath the limestone just mentioned [grey nummulitic], which, however, is traceable along their flank and reappears in the Taptee river at the end of the range, being let down by a fault to a lower level, but preserving its westerly dip, and seen to be overlain again by another band of laterite."

Here it appears that laterite is both below and above Nummulitic limestone. There can thus be no doubt that this laterite belongs to the Lower Eocene. The rocks of the Nummulitic series near Gulla on the Taptee, at the distance of a few miles south of Turkeysur, are reported by Mr. Wynne to overlie those of the latter place, and are thus a little higher in the Eocene. The laterite in the neighbourhood of Turbhan, to the south-east of Surat, is described in the same report as compact and brecciated, and as being of a very similar character to that just mentioned. There seems to be no doubt that this laterite is precisely similar in mineral character to that of the Deccan, which caps the western Ghauts or Syhadree range, Mahableshwur, &c., frequently at the top of precipitous scarps thousands of feet in height above the level of the low country of Goozerat. There is no apparent reason for supposing that the laterites of the high and low levels are referable to at all widely separated geological ages, the evidence of the agate conglomerates near Turkeysur, intercalated between lateritic beds, being the only proof of the rock having been deposited at different times.

Mr. Blanford, in reporting on the age of the traps, admits that denudation must have taken place to an immense extent after the Nummulitic rocks were deposited; and the rare occurrence of laterite in the low country may probably be attributed to this. Subsequent upheaval, too, is proved by the position of the lateritic beds to the south of Gogo; these have been broken up from below, and lie as they were thrown over on the flanks of some of the hills. This might account for the disruption of the Island of Perim from the mainland; but only a much more violent action would have separated the laterites of the high and low levels, supposing them to have been deposited under similar geological circumstances. This rock, again, appears at precisely the same level on the opposite sides of valleys in the Concan and Deccan, giving ample proof of denuda-

tion; but under what circumstances this could have taken place, and whether before or subsequently to the deposition of the laterite in the low country of Goozerat, does not seem to have been inquired into. The inquiry may be recommended to Indian geologists as one of great interest.

P.S.—Since writing the foregoing remarks on the probability of the Indus or some large river from the north having once found its way into the Gulf of Cambay, I have seen quotations from Prof. Max Müller's translation of the Vedas, which prove that at the time some of them were composed, the Suruswuttee, the most easterly of the Punjaub rivers, which now loses itself in the desert of Rajpootana, flowed into the Indian Ocean. This confirms to some extent the theory of the cause of the alluvial deposit at the head of the Gulf of Cambay.

---

3. *On the* Rodentia *of the* Somerset Caves. By W. A. Sanford, Esq., F.G.S.

(Read June 23, 1869*.)

[Plate VIII.]

Having recently examined the collection of Rodentia from the Somerset Caves in the Taunton Museum, I find that several of the specimens cannot be referred to species which have hitherto been considered members of the fauna cotemporary with the Mammoth (*Elephas primigenius*) in Britain.

1. Genus *Arvicola*.—As usual, bones and teeth of one or the other of the closely allied species, or perhaps varieties, which are about the size of, and have a dentition similar to that of *Arvicola amphibius*, abound in the Somerset Caves; but they are all fragmentary, and, as the observed differences between these species principally depend on the proportions of different parts of the animals, and not upon differences of form of the parts themselves, it is useless with our present materials to attempt to determine to which of these forms the fossils belong; it will be convenient to class them, as hitherto, as the bones of our common Water-rat (*Arvicola amphibius*, Linn.).

2. *Arvicola glareolus* (Schreber)=*pratensis* (Baillon)=*riparia* (Yarrell), appears to be a rare cave animal. We have never met with but two jaws; one of them is from Hutton Cave, and is in the Taunton Museum.

3. We have met with several lower jaws the dentition of which is identical with that of *Arvicola agrestis* (Linn.); but the diastema between the molars and incisor is longer, and the lower jaw itself is straighter in this part than in the recent jaws with which we have compared it. In this the jaws approach *Arvicola ratticeps* (Blasius); but we do not regard the difference as other than varietal.

4. Among the bones hitherto referred to *Arvicola agrestis* we

* See p. 444 of the last volume.

found the anterior part of a skull (Pl. VIII. fig. 1, *a*, *b*, *c*, *d*) and several lower jaws of a larger form. These appear to be undistinguishable from those of *Arvicola ratticeps* = *Lemmus medius* (Neilson), the recent animal being an inhabitant of Russia, Western Siberia, and Norway.

The lower jaw is easily recognizable by the formation of the anterior molar (Pl. VIII. fig. 1, *d*), in which the two anterior columns coalesce on the external surface, while they are well defined internally. The upper dentition closely resembles that of *Arvicola agrestis*; but the posterior molar differs slightly, but constantly, in form (Pl. VIII. fig. 1, *a*). Excellent plans of the teeth of these four forms are to be found in Blasius, 'Wirbelthiere Deutschlands,' from which a clearer idea of the minute differences which characterize the species can be obtained than from the most detailed description.

5. Five lower jaws (Pl. VIII. fig. 2 *a*, *b*) exist in the Taunton Museum, which we cannot refer to any recent or fossil form with which we are acquainted: they are nearly as large as those of *Arvicola amphibius*; a depression usually found on the internal surface of the mandible, under the alveolar border of two anterior molars, does not exist in these jaws; this gives the jaw a peculiarly robust appearance. The chief peculiarity is in the dentition, which closely resembles that of *Arvicola subterraneus* (De Selys), one of the most minute forms of the genus. The anterior and characteristic molar (Pl. VIII. fig. 2 *b*) has six equally developed columns on the inside, and five externally; these give, on the plan of the tooth, nine well-marked triangles, the anterior and posterior of which form both internal and external columns or, rather, buttresses. We have met with no recent teeth so large as these, with this amount of complication. It is possible that *Arvicola ambiguus* of the Brêches de Coude, described by M. Pomel, may be of the same species; but we have had no opportunity of comparing the specimens, and have seen no description of the teeth; we therefore propose to name the form provisionally *Arvicola Gulielmi*, after the energetic explorer of the Somerset caves, the Rev. D. Williams.

6. Genus *Lemmus*.—We find six lower jaws, which most closely resemble those of *Lemmus norvegicus* (Desmarest); they are, however, slightly smaller, and the condyle, with its neck, is slightly more slender in proportion to the size of the jaw: we cannot, with our present means of information, ascribe to these differences a greater than varietal value (Pl. VIII. fig. 3, *a*, *b*).

7. The anterior portion of a skull exhibits a form of dentition and some other peculiarities which show the animal to which it belonged to be as closely allied to *Lemmus torquatus* (Desmarest) as the before-mentioned jaws are to *Lemmus norvegicus*: the difference appears to be solely that of size, the fossil being larger than the recent specimens in the British Museum with which we have compared it. It is probably identical with the animal which Dr. Blackmore found in the Fisherton deposits near Salisbury. The posterior upper molar of *Lemmus norvegicus* and *Lemmus obensis* is of a totally different form from that of *Lemmus torquatus* and *grœnlandicus*, the

columns of which it is composed being pressed together so as to allow of no interval between them, whereas in the last two it is of the ordinary Arvicoline character; but they have four columns both externally and internally. The penultimate molar has three columns both externally and internally, and the anterior three internally and four externally; and *L. torquatus* is further distinguished by a minute accessory posterior column to these two teeth. In all these characters the fossil closely agrees with *L. torquatus*, as well as in the form of the palatine aspect of the maxillaries and palatine bones, and of the naso-palatine foramen, whereas it differs from the other three species in these respects. The agreement in size between this upper jaw and the lower jaws last described is singular, and indicates the possibility that they may have belonged to the same animal; but as I have shown that *L. torquatus* and *L. norvegicus* belong to different sections of the genus, it is hardly probable that we have in the fossil an animal uniting the characteristics of the lower jaw of the one to the upper jaw of the other. We think it safer, for the present, to describe one as a small variety of *L. norvegicus*, and the other as a large variety of *L. torquatus* (Pl. VIII.) fig. 4, *a*.

8. Genus *Lagomys*.—*Lagomys spelæus* (Owen) has yielded two lower jaws—one from Hutton, found by Mr. Beard, and a second, found by Mr. Williams, which exactly corresponds in condition with it. Both are stouter than the specimens of *Lagomys pusillus* with which they have been compared; but the cave-Pika was certainly variable in this respect, and some jaws we have recently met with in Kent's Hole do not appear to be larger or stouter than the small recent Siberian animal; in other respects they coincide: we therefore consider it most probable that the cave animal was a variety of *Lagomys pusillus*.

9. Genus *Lepus*.—In examining very numerous bones of *Lepus* which we have met with, which are found side by side with the bones of *Elephas primigenius* and its associated fauna, and comparing them with those found in more recent beds, and with the bones of *Lepus timidus*, we have been much struck by the almost uniformly larger size of all the bones, particularly of the skulls of the more ancient animal. The same thing appears also to have struck the French palæontologists; they have consequently named the larger and stouter form *Lepus diluvianus* (Pictet).

A complete skull (Pl. VIII. fig. 5), many and considerable fragments of others, and a large number of lower jaws and of other bones have enabled us to make a comparison for which no previous opportunity appears to have existed. These bones are from Hutton, Banwell, and several other Mendip caves, as well as from Kent's Hole and some other localities out of the county of Somerset.

In the examination of the skulls of hares generally, when a large series of individuals, as well as of species, is compared, we have found that what at first might appear to be a specific difference is so frequently obliterated by individual variation, that it is extremely difficult to seize characters by which even entire skulls can be diffe-

rentiated. But the entire skull and the many fragments in the Taunton Museum differ far more from any recent skulls with which we have been able to compare them than almost any of those of the existing species of the restricted genus *Lepus* do from each other. A reference to the table of measurements at the end of this paper will show the almost gigantic size of the fossil form.

A minute description of the skull and other bones would require an undue amount of space; but the following are a few of the most salient characters which appear to be constant. The frontals differ in form from those of every hare with which we have compared them, with the exception of those of the much smaller form, *Lepus altaicus* of the British Museum Catalogue; but in the skulls of this animal the postorbital processes are much less developed, and do not extend as far back as the parietals, with which these processes coalesce in the fossil. In this respect the fossil agrees with the Rekalek or Polar hare, *Lepus arcticus*; it also resembles this animal in the comparatively great depth of the malar; but in no other respect have the animals any near affinity, the skull being comparatively much longer. From all other hares with which we have compared it, it differs by the depression on the malar being carried much further forward, by the angle formed by this bone with the ascending process of the maxillary which forms the anterior border of the orbit being much more distinctly marked and less rounded off, as well as by the greater development of the posterior process of the malar. We have found too much individual variation in the minute comparative measurements of the different bones of the skull to trust to any of them as specific distinctions; but the aspect of the whole skull (independent of its size) is so different when placed among a large number of recent crania that it is impossible not to be at once convinced of its distinctness (Pl. VIII. fig. 5).

The greater number of the other bones of the skeleton confirms this opinion; for, though not much longer, they are almost invariably much larger and stouter, when found with the older fauna, than those of any recent hares to which we have had access.

10. Although by far the larger proportion of the bones of hares from the deposits in which the Mammoth-fauna occurs are of the stout and comparatively gigantic form, a certain though small number cannot be distinguished from those of *Lepus timidus* (Linn.), which we must therefore class as belonging to this fauna, whereas in the caves which were more recently filled, such as Whitcombe's Hole in the Mendip, which contained sheep, none of the larger bones are found; they are exclusively those of the common hare and the rabbit.

The same has occurred to us in another locality, the details of which we are not at present in a position to publish.

11. *Lepus hibernicus* (Bell). A single half lower jaw from Hutton Cave may doubtfully be referred to this species: it is too mutilated and belonged to too young an animal to be determined absolutely.

12. *Lepus cuniculus* (Linn.). With regard to this animal, we think that, without more exact evidence than we have as yet met with, considerable doubt must exist as to its having been really contemporaneous with the Mammoth in these islands. Professor Owen, in the 'British Fossil Mammals,' merely refers to several instances of the occurrence of its bones in caves, without any further notice of their state or position in the deposit; and the same remark may be made with regard to the notice of the animal by Dr. Buckland, in 'Reliquiæ Diluvianæ,' p. 19. The burrowing habits of the animal are such that, unless the bones are found imbedded in such a position, and in such condition, that there cannot be any reasonable doubt of their date, we must be most cautious as to admitting the rabbit as an undoubted member of the Mammoth-fauna. We have examined a very large number of bones from different British caves, but have never found those of the rabbit in breccia or in old stalagmite—in fact, in anything but the soft cave earth, and that extremely rarely. Now, in the more recent deposits in the caves, *i.e.* in those which contain domestic animals, the rabbit is one of the most abundant fossils; and when its known fecundity is taken into account, it is extremely difficult to imagine why, if it coexisted at all with the Mammoth, its bones are not more abundant in the deposits which contain that animal. Yet with the evidence we have from Wookey Hyæna-den, from Hutton, and, in a single instance, from Kent's Hole, it is necessary for us to insert provisionally, as it were, the rabbit as one of the rarest members of the Mammoth-fauna; for from each of the above it occurs in our collections, although very rarely, in apparently the same state as the remains of extinct animals. Still, without actual examination and notes taken at the time, we are without evidence as to the possibility or otherwise of the animal having burrowed into the place in which its bones occurred.

13. Genus *Spermophilus*.—The insertion of *Spermophilus citillus* in a list of the Pleistocene Mammalia, published some time since by Mr. Boyd Dawkins and myself, was founded on a mistake which it is necessary to explain:—

A late curator of the Taunton Museum altered the label on one of the specimens of *Spermophilus erythrogonoides*, which had been described by Dr. Falconer, to *S. citillus*. We, supposing that he had the authority of Dr. Falconer for the determination, placed the species in our lists without further examination. When, however, we came to examine the collection, specimen by specimen, we at once discovered our error; and on the publication of Dr. Falconer's posthumous Memoirs, we found that Dr. Falconer had attributed both jaws to *S. erythrogonoides*. A third jaw, among bones from Bleadon cave, which had belonged to Mr. Williams, has since been discovered.

14. Genus *Cricetus*.—The last species we shall notice is *Cricetus* (*Mus*) *songarus* (Pallas). It is known that Mr. Williams discovered in the Hutton cave what he considered to be the bones (including parts of the skulls) of mice. No such occur in his collection; but we find that which he might have easily mistaken for them—the

anterior parts of two skulls, and two rami of lower jaws of a small species of *Cricetus* which so closely resemble those of *Cricetus songarus,* though very slightly larger than the specimens we have compared them with, that we must, for the present at least, refer them to that species. It is possible that this is the same species as that described by M. Pomel, from the Brêches de Coudes, as *Cricetus musculus.* *Cricetus songarus* at present inhabits Russia and western Siberia.

Measurements.

Lepus diluvianus.

	in.
Basal length of skull from foramen magnum to anterior portion of intermaxillary	3·42
Extreme length	4·36
Height of skull from alveolar border of M 1 to highest part of frontal	1·54
Width, extreme, at squamosals	2·00
Basal length of basioccipital	0·56
,, ,, basisphenoid	0·56
,, ,, præsphenoid	0·32
Length of suroccipital	0.58
Width ,, ,,	1·10
Length of parietals	0·96
Width ,, ,,	1·23
Length of frontals	1·71
Width of frontals (double the half)	1·31
Length of nasals	1·49
Width of nasals (extreme)	0·90
,, ,, (minimum)	0·83
Width of malar	0·40
Malar process of maxillary to posterior end of malar	1·43
Diastema between incisors and PM 2	1·27
Molar series	0·77

Lower jaw—

Total length, not including incisor	2·76
Depth at M 1	0·62
Depth from condyle to angle	1·90
Length of diastema	0·89
Molar series	0·75

		Width.	Length.
		in.	in.
Dentition, upper	PM 2	0·16	0·08
	PM 3	0·22	0·12
	PM 4	0·25	0·11
	M 1	0·24	0·13+
	M 2	0·20	0·11
	M 3	0·09	0·05
,, lower	PM 3	0·12+	0·16
	PM 4	0·15	1·12
	M 1	0·14	0·14
	M 2	0·14	0·12+
	M 3	0·10	0·10

Arvicola Gulielmi.

Lower jaw—

	in.
Length extreme, not including incisor	0·84
Depth, coronoid process to lower edge	0·38
Depth at M 2	0·12
„ at PM 4	0·22
Diastema	0·23
Molar series	0·29

	Length.	Width.
PM 4	0·14	0·06
M 1	0·80	0·06
M 2	0·60	0·05

Arvicola ratticeps.

Upper jaw—

	Length.	Width.
Diastema	0·32	
Molar series	0·28	
PM 4	0·11	0·6
M 1	0·10	0·5
M 2	0·70	0·4

Lower jaw—

	Length.	Width.
Condyle to anterior border of incisor	0·65	
Lower edge of angle to symphysis	0·43	
Depth of coronoid process to lower edge	0·30	
Depth at M 2	0·08	
Diastema	0·18	
Molar series	0·24	
PM 4	0·12	0·05
M 1	0·06	0·05
M 2	0·05	0·04

Lemmus torquatus (var.)

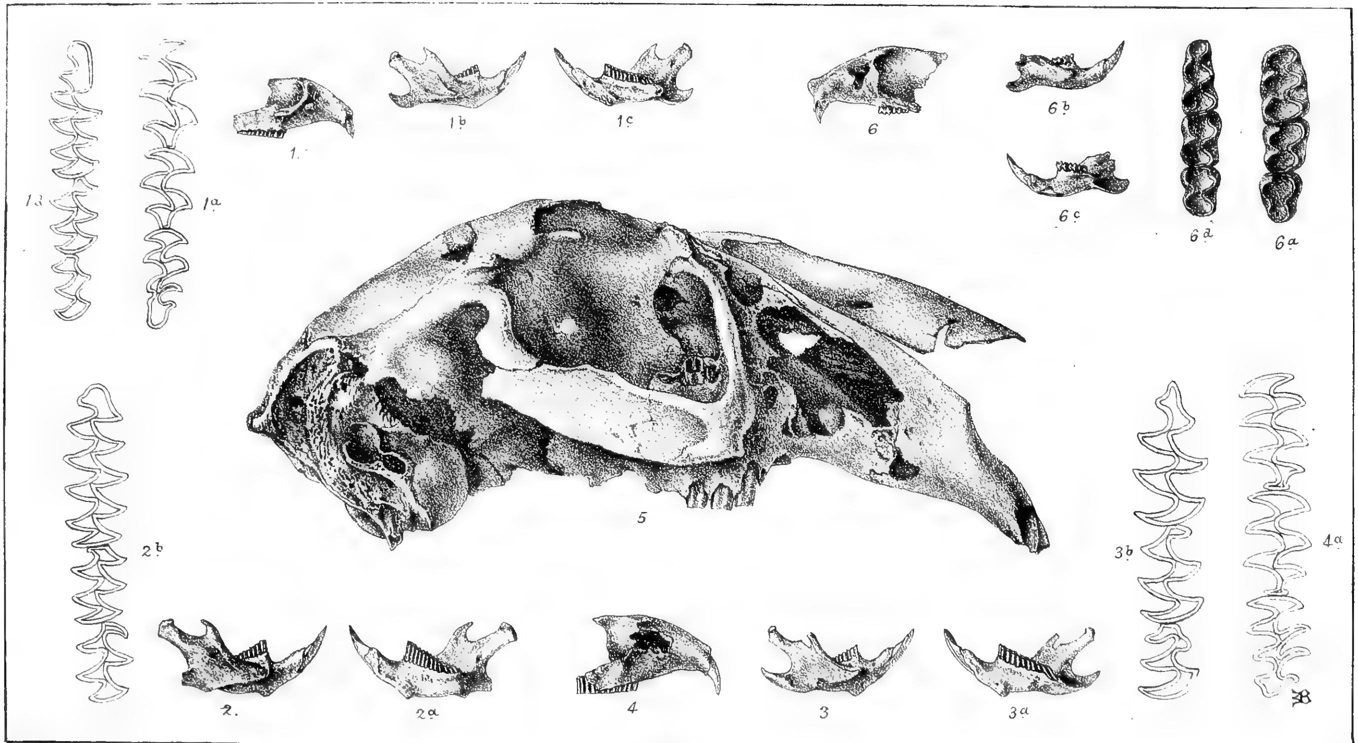
Upper jaw—

	Length.	Width.
Diastema	0·37	
Molar series	0·29	
PM 4	0·12	0·07
M 1	0·09	0·06
M 2	0·09	0·06

Lemmus norvegicus (var.).

Lower jaw—

	Length.	Width.
Length, extreme	0·70	
Angle to symphysis	0·51	
Diastema	0·22	
Molar series	0·27	
PM 4	0·13+	0·07
M 1	0·08+	0·06
M 2	0·08+	0·06



W. Bidgood del et lith.

W. West imp

Cricetus songarus.

Upper jaw—

	Length.	Width.
Diastema	0·30	
Molar series	0·19	
PM 4	0·07	0·05–
M 1	0·05+	0·05–
M 2	0·04–	0·04

Lower jaw.

	Length.	Width.
Diastema	0·18	
Molar series	0·17	
PM 4	0·07	0.05–
M 1	0·06	0·05–
M 2	0·05	0·04–

EXPLANATION OF PLATE.

Plate VIII.

Fig. 1. *Arvicola ratticeps.* Upper jaw, lateral aspect.
1 *a.* Dentition of the upper jaw, magnified six diameters.
1 *b.* Lower jaw, external aspect.
1 *c.* The same, internal aspect.
1 *d.* Dentition of the lower jaw, magnified six diameters.
2. *Arvicola Gulielmi*, n. s., lower jaw, external aspect.
2 *a.* The same, internal aspect.
2 *b.* Dentition of the same, magnified six diameters.
3. *Lemmus norvegicus* (var.), lower jaw, external aspect.
3 *a.* The same, internal aspect.
3 *b.* Dentition of the same, magnified six diameters.
4. *Lemmus torquatus* (var.), anterior part of the skull, lateral aspect.
4 *a.* Dentition of the same, magnified six diameters.
5. *Lepus diluvianus*, skull, natural size, lateral aspect.
6. *Cricetus songarus*, anterior portion of skull, lateral aspect.
6 *a.* Dentition of the above, magnified six diameters.
6 *b.* Lower jaw, external aspect.
6 *c.* The same, internal aspect.
6 *d.* Dentition of the lower jaw, magnified six diameters.

DONATIONS

TO THE

LIBRARY OF THE GEOLOGICAL SOCIETY.

From July 1st to September 30th, 1869.

I. TRANSACTIONS AND JOURNALS.

Presented by the respective Societies and Editors.

Academy (Journal). No. 1. (9 October, 1869.)

Altenburg. Mittheilungen aus dem Osterlande. Band xviii. Hefte 3 & 4. 1868.

American Journal of Science and Arts. Second Series. Vol. xlviii. No. 142. July 1869.

F. B. Meek and A. H. Worthen.—Notes on some points in the Structure and Habits of the Palæozoic Crinoidea, 23.
O. C. Marsh.—Description of a new Species of *Protichnites* from the Potsdam Sandstone of New York, 46 (1 plate).
E. Billings.—Notes on the structure of the Crinoidea, Cystidea, and Blastoidea, 69.
B. Silliman.—Note on Wollongongite, a remarkable Hydrocarbon found in the Wollongong District of the Illawarra Coal-field, New South Wales, 85.
W. P. Blake.—On the Precious Metals, 126.
S. F. Peckham.—On the origin of Bitumens, 131.
'Geological Survey of California,' vol. ii., noticed, 133.
Mineral resources of the country west of the Rocky Mountains, 136.

American Naturalist. Vol. ii. (Duplicate.)

——. Vol. iii. Nos. 5–7. July to September 1869.

Anthropological Review. No. 26. July 1869.

R. Owen's 'Comparative Anatomy of Vertebrates,' vol. iii., noticed.

Artisan (Journal). Vol. iii. Nos. 5–7.

Athenæum (Journal). Nos. 2175–2187. June to August 1869.

Hardwick.—Notes on the Geology of North Shropshire, 328.

Basle. Verhandlungen der naturforschenden Gesellschaft in Basel. Theil v. Heft 2. 1869.

A. Müller.—Ueber die Umgebungen des Crispalt, 194.
——. Ueber einige erratische Blöcke im Kanton Basel, 247.
P. Merian.—Ueber einige Tertiär-Versteinerungen von Thewyyler bei Basel, 252.
——. Die Versteinerungen von St. Verena bei Solothurn, 255.

Berlin. Monatsbericht der königl.-preussischen Akademie der Wissenschaften zu Berlin. April to June 1869.

C. G. Ehrenberg.—Ueber den am 24. März dieses Jahres mit Nord-Ost-Sturm gefallenen rothen Passatstaub in den Dardanellen und dessen Verbreitung über Griechenland and Krain, 308.
G. Rose.—Ueber die regelmässigen Verwachsungen der verschiedenen Glimmerarten, 339.
C. G. Ehrenberg.—Ueber mächtige Gebirgsschichten, vorherrschend aus mikroskopischen Bacillarien unter und bei der Stadt Mexiko, 373.

——. Zeitschrift für die gesammten Naturwissenschaften. Vol. xxxii. 1868.

Boston (U.S.). Memoirs read before the Boston Society of Natural History. Vol. i. Part 4. 1869.

George L. Vose.—On the Distortion of Pebbles in Conglomerates, with illustrations from Rangely Lake, in Maine, 482 (3 plates).
William T. Brigham.—The Eruption of the Hawaiian Volcanoes, 1868, 564.

——. Proceedings of the Boston Society of Natural History. Vol. xii. Sheets 1–17. June 1868 to March 1869.

W. T. Brigham.—Eruption of Mauna Lòa, 82.
C. T. Jackson.—Apatite in Canada West, 88.
N. S. Shaler.—On the Nature of the Movements involved in the Changes of Level of Shore Lines, 128.
R. von Schlagintweit.—On Nephrite, from Turkistan, 138.
W. H. Dall.—On Alaska, 143.
N. S. Shaler.—On the absence of traces of glacial action in the Valley of the Yukon River, in the northern part of Alaska, 145.
E. S. Morse.—On the Land-slides in the Vicinity of Portland, Maine, 235 (1 plate).
E. D. Cope.—On the Reptilian Orders Pythonomorpha and Streptosauria, 250.

British Association for the Advancement of Science. Meeting at Norwich, 1868. 8vo. 1869.

W. Pengelly.—Fourth Report of the Committee for exploring Kent's Cavern, Devonshire, 45.
H. Woodward.—Fourth Report on the Structure and Classification of the Fossil Crustacea, 72.
P. M. Duncan.—First Report on the British Fossil Corals, 75.

British Association for the Advancement of Science. Meeting at Norwich (*continued*).

C. Moore.—Preliminary Report on Mineral Veins containing Organic Remains in the Carboniferous Limestone, 428.

R. A. C. Godwin-Austen.—Presidential Address, Section C, 51.

W. H. Baily.—Fossils from the Old Red Sandstone of Kiltorcan Hill, Kilkenny, 58.

A. Bell.—Molluscan Fauna of the Red Crag, 59.

J. Brodie.—Recent Geological changes on the British Islands, 60.

Hyde Clark.—Western Asia Minor Coal- and Iron-basins, and the Geology of the District, 61.

E. Crisp.—Skeleton of a Fossil Whale from the Eastern Coast of Suffolk, 61.

H. Coquand.—Parallelism of the Cretaceous Strata of England and the North of France with those of the West, South-west, and South of France and the North of Africa, 61.

P. M. Duncan.—On the genus *Clisiophyllum*, 62.

O. Fisher.—On the Denudations of Norfolk, 63.

W. Fox.—On the Skull and Bones of an Iguanodon, 64.

W. R. Grove.—Artificial Rocking-stones, an experiment, 65.

J. Gunn.—On the Alternate Elevations and Subsidences of the Land, and the order of Succession of Strata in Norfolk and Suffolk, 66.

H. Hicks.—On some recent Discoveries of Fossils in the Cambrian Rocks, 68.

C. Jecks.—On the Ferruginous Sandstone of the Neighbourhood of Northampton, 69.

E. R. Lankester.—On the Oldest Beds of the Crags, 70.

J. L. Lobley.—On the Range and Distribution of the British Fossil Brachiopoda, 71.

J. Lowe.—On the occurrence of Spherical Iron Nodules in the Lower Greensand, 72.

Dr. Mann.—On the Coal-field of Natal, 73.

G. Maw.—On the Sequence of the Deposits in Norfolk and Suffolk superior to the Red Crag, 73.

C. Moore.—On New Discoveries connected with Quaternary Deposits, 74.

C. G. Nicolay.—On the Geology of the Chapada Diamantina in the province of Bahia, Brazil, 74.

C. W. Peach.—On the Fossil Fishes of Cornwall, 76.

W. Pengelly.—On the condition of some of the Bones found in Kent's Cavern, Torquay, 76.

C. B. Rose.—On the Crag at Aldeby, 77.

J. W. Salter.—On a New *Pterygotus* from the Lower Old Red Sandstone, 78.

S. Sharp.—On a remarkable Incrustation in Northamptonshire, 78.

J. Tennant.—On the recent Discovery of Diamonds in the Cape Colony, 79.

J. Thomson.—Notes on certain Reptilian Remains found n the Carboniferous Strata of Lanarkshire, 79.

O. Torell.—On some New Fossils from the Longmynd Rocks of Sweden, 80.

F. W. Harmer.—On the Glacial and Postglacial Structure of Norfolk and Suffolk, 80.

Calcutta. Asiatic Society of Bengal. Proceedings. Nos. 5–7 (May to July), 1869.

Calcutta. Journal of the Asiatic Society of Bengal. New Series. Part 1. No. 2, and Part 2. Nos. 2 & 3. 1869.

Cambridge. Proceedings of the Cambridge Philosophical Society. Parts 3–6.

H. G. Seeley.—The Laws which have determined the distribution of Life and Rocks (abstract), 39.
——. On the Potton Sands (abstract), 43.
Rev. O. Fisher.—On Roslyn or Roswell Hill Clay-pit, near Ely, 51.
H. Seeley.—On the Association of Potton Sand Fossils with those of the Farringdon Gravels in a phosphatic deposit at Upware, on the Cam; with an account of the Superposition of the Beds, and the significance of the Affinities of the Fossils, 99.
F. A. Paley.—On a Series of Elevated Sea Terraces on Hampsfell, near Cartmel, Lancashire, 107.

——. Transactions of the Cambridge Philosophical Society. Vol. xi. Part 2. 1869.

D. T. Ansted.—On some phenomena of the Weathering of the Rocks, illustrating the nature and extent of subaërial denudation, 387.

Canadian Naturalist and Geologist. Vol. iii. Nos. 5 & 6.

J. W. Dawson.—Notices of some remarkable Genera of Plants of the Coal Formation, 362.
F. G. Matthew.—On the Azoic and Palæozoic Rocks of Southern New Brunswick, 387.
S. Lovén.—On *Leskia mirabilis* (Gray), 437.
T. Macfarlane.—On the Extraction of Copper from Ores in the Humid Way, 457.

——. Vol. iv. Nos. 1 & 2.

G. F. Matthew.—On the occurrence of Arctic and Western Plants in Continental Acadia, 139.
T. S. Hunt.—On the probable seat of Volcanic Action, 166.

Chemical News. Vol. xx. Nos. 500–513.

Chemical Society. Journal. Second Series. Vol. vii. July to September 1869.

Colliery Guardian. Vols. xvii. & xviii. Nos. 443–456.

Darmstadt. Notizblatt des Vereins für Erdkunde und verwandte Wissenschaften zu Darmstadt, und des mittelrheinischen geologischen Vereins. Herausgegeben von L. Ewald. 3te Folge. Heft 7. 1868.

R. Ludwig.—Phosphorsaurer Kalk im Schalstein bei Königsberg im Hinterland, 158.
——. Die von oberdevonischen Gesteinen ausgefüllte Falte von Buchenau, 158.
——. Versteinerungen im Dachschiefer von Gladenbach im Hinterland, 191.
——. Neue Corallen aus dem Mittel-Devon von Biedenkopf, 191.

Dresden. Sitzungs-Berichte der naturwissenschaftliche Gesellschaft Isis in Dresden. Jahrg. 1869. Nos. 4–6. April to June.

— Geinitz.—Ein Ausflug in das Erzgebirge, 65.

— Günther.—Einiges über in der Menschenzeit ausgestorbene Thiere, 68.

— Geinitz.—Ueber *Nemapodia tenuissima* Emm. und *Nereograpsus tenuissimus* Gein., 79, 80.

——. Ueber ein vermeintliche versteinerte Gehirn, 83.

Dublin. Journal of the Royal Geological Society of Ireland. Vol. ii. Part 1. 1868.

J. Beete Jukes.—On the Subdivisions of the Carboniferous Formation in Central Ireland, 1.

W. Andrews.—On Oyster Deposits, 13.

A. Gahan.—Columnar Structure occasionally exhibited by Mortar, 15.

J. S. Moore.—On the Antiquity of Man, 16.

W. Harte.—On the Post-tertiary Geology (Recent and Post-Pliocene phenomena) of the county of Donegal, and part of the county of Derry, and its connexion with that of Scotland, 30.

J. Beete Jukes.—Notes on Parts of South Devon and Cornwall, with Remarks on the True Relations of the Old Red Sandstone to the Devonian Formation, 67.

–– Nelson.—Illustrations of the Extinct Volcanoes of the Eifel, 107.

H. Lloyd.—Notes on the Kammerbuhl, an extinct Volcano in Bohemia, 109.

S. Haughton.—Additional Notice of the Zeolites of Western India, 112.

A. Macalister.—On the Anatomical and Ethnological characters of the Skull of an Aboriginal Inhabitant of Chatham Island, 115.

——. Journal of the Royal Dublin Society. Vol. v. No. 38. 1869.

Dr. Barry.—On the Physical Geography of the South Atlantic, 277.

R. Alloway.—On Peat, and its profitable Utilization, 281.

W. Thomson.—On the Depths of the Sea, 316.

Economist (Journal). Vol. viii. No. 38.

Geneva. Mémoires de la Société de Physique et d'Histoire Naturelle de Genève. Tome xx. Première partie. 1869.

Geological Magazine. Vol. vi. Nos. 7–9. July to September 1869.

W. Carruthers.—Cryptogamic Forests of the Coal-period, 289.

T. Davidson.—Notes on Continental Geology, including a sketch of the Geology of Nice, 300.

T. P. Barkas.—Notes on the species of *Ctenodus* from the Coal-measures, 314 (plate 9).

H. Woodward.—Note on *Cetnodus tuberculatus*, 317.

J. Morris.—The Lead-bearing districts of the North of England, 317.

The Miocene Flora of North Greenland, 322.

The Teyler Museum and Winkler's Descriptions of Fossil Turtles, 324.

——. On the Genus *Æchmodus* from the Lias of Lyme Regis, 337 (plate 10).

H. B. Medlicott.—On Faults in Strata, 341.

Geological Magazine. Vol. vi. Nos. 7–9 (*continued*).

H. C. Sorby.—On the Excavation of Valleys in Derbyshire, 347.
G. H. Kinahan.—Additional Notes on the Growth of Soil, 348.
J. Rofe.—On the Enlargements on some Crinoidal columns, 351.
R. Lightbody.—On the Geology of Ludlow, 353.
E. R. Lankester.—On a new Crag Mastodon, 355.
The Centenary of William Smith's Birth, 356.
C. Montagna.—On the Metamorphism of Rocks, 359.
Blake 'On the Production of the Precious Metals,' reviewed, 361.
Page's 'Chips and Chapters for Geologists,' reviewed, 363.
Newberry 'On the later Extinct Floras of North America,' reviewed, 364.
'Transactions of the Manchester Geological Society,' reviewed, 365.
H. Woodward.—The Freshwater deposits of the Lea Valley, 385.
R. Owen.—On the occurrence of the Elk in British Post-tertiary Deposits, 389.
J. A. Mahony.—On the Organic Remains found near Crofthead, Renfrewshire, 390.
J. G. O. Linnarsson.—On Fossils in the Eophyton Sandstone in Sweden, 393 (3 plates).
G. H. Kinahan.—On the Formation of Raimes by Recent Drift Accumulations, 406.
Sir P. de M. Grey-Egerton.—Catalogue of typical Fossil Fishes in his collection, 408.
Royal Commission on the Water-supply of London, 414.
Foster's 'Mississippi Valley,' reviewed, 421.
'Geological Tables,' reviewed, 423.
'Geological Survey of Illinois,' reviewed, 425.
Proceedings of Societies, 324, 366, 428.
Correspondence, 333, 380.
Obituary, 430.

Halifax. Proceedings and Transactions of the Nova-Scotian Institute of Natural Science. Vol. ii. Part 2. 1867–68.

Prof. How.—Notes on the Economic Mineralogy of Nova Scotia, 26.
P. S. Hamilton.—On Submerged Forest Trees in Cumberland Basin, 94.

Historic Society of Lancashire and Cheshire. Transactions. New Series. Vol. viii. 1868.

Institution of Civil Engineers. Minutes of Proceedings. Vol. xxvii. 1867–68.

P. P. L. O'Connell.—On the Relation of the Fresh-water Floods of Rivers to the Areas and Physical Features of their Basins, 204.
A. C. Howden.—Floods in the Nerbudda Valley; with remarks on Moonsoon Floods in India, 218.

——. ——. Vol. xxviii. 8vo. 1868–69.

W. H. Wheeler.—The River Witham, 59.
D. T. Ansted.—On the Lagoons and Marshes of certain parts of the Shores of the Mediterranean, 287.
W. Shelford.—On the Outfall of the River Humber 72.

Linnean Society of London. Transactions. Vol. xxvi. Part 3. 1869.

——. Proceedings. 1868–69, pp. lxv–cxxxiv.

——. Journal. Vol. x. Zoology, No. 46; and Vol. xi. Botany, Nos. 50 & 51. 1869.

——. ——. Botany, Vol. xii. 1869.

London, Edinburgh, and Dublin Philosophical Magazine. Fourth Series. Vol. xxxviii. Nos. 252–254. July to September, 1869.

J. Croll.—On the Opinion that the Southern Hemisphere loses by Radiation more heat than the Northern, and the supposed Influence that this has on Climate, 220.

Longman's Notes on Books. No. 58. August 1869.

Manchester. Memoirs of the Literary and Philosophical Society of Manchester. Third Series. Vol. iii. 8vo. London, 1868.

R. D. Darbishire.—Notes on Marine Shells found in Stratified Drift, near Macclesfield, 56.

E. W. Binney.—Further Observations on the Permian and Triassic strata of Lancashire, 108.

——. Proceedings of the Literary and Philosophical Society of Manchester. Vol. v. 1866.

— Hardy.—Large Cetacean Vertebra from the Valley of the Don, 32.

E. W. Binney.—Calcareous nodules with fossil wood from the Lower Coal-seams of Lancashire and Yorkshire, 61, 113.

W. Brockbank.—On a Section of Chat Moss, near Astley Station, 91.

E. Hull and W. Brockbank. On the Liassic and Oolitic Iron-ores of Yorkshire and the East Midland Counties, 119.

——. ——. Vol. vi. 1867.

E. W. Binney.—Specimens from a bore-hole at Birkdale, 17.

——. On two fossil Specimens of a species of *Calamites* from the Carboniferous Strata of Great Britain, 46.

——. Fossil Insects from the Lower Coal-measures near Huddersfield, 59.

——. Section of the Drift and Underlying Triassic and Coal-measures at Ardwick, 119.

E. Hull.—On a Section of the Drift Deposits in the Banks of the Ribble, near Balderston Hall, 136.

——. ——. Vol. vii. 1868.

E. W. Binney.—On some Specimens and Sections of *Volkmannia*, 1.

R. D. Darbishire.—On *Pholas*-burrows in the Limestone Hills near Buxton, 7.

——. Notes on some Superficial Deposits at Great Orme's Head, and the Period of its elevation, 12.

E. W. Binney.—On the Posidonian schists of the Isle of Man, 27.

——. On the Age of the Hæmatite Iron Deposits of Furness, 55.

——. On *Pholas*-borings in Furness and Cartmel, 76.

——. Description of a Dolerite at Gleaston, in Low Furness, 148.

Manchester. Transactions of the Manchester Geological Society. Vol. viii. Part 4. 1869.

J. Warburton.—On the Working of Mines, 53 (1 plate).

Medical Press and Circular. New Series. Vol. viii. Nos. 1–13.

Milan. Atti della Società Italiana di Scienze Naturali. Vol. xi. Fasc. 2. October 1868.

L. Bombicci.—Notizie intorno alcuni minerali Italiani (*continued*), 129 (2 plates).
G. Negri.—Dell' Opera di Alfonso Favre: Recherches géologiques dans les parties de la Savoie, &c., 137.
G. Ponzi.—Sopra un nuovo ordinamento geologico dei terreni subappennini, 181.

——. Rendiconti del Reale Istituto Lombardo di Scienze e Lettere. Serie ii. Vol. i. Fasc. 11–20. 1868.

——. ——. Vol. ii. Fasc. 1–10. 1869.

L. Maggi.—Intorno ai depositi lacustro-glaciali ed in particolare di quelli della Valcuria, 41.

——. Solenni adunanze del R. Istituto Lombardo di Scienze e Lettere. 7 Agosto, 1868.

——. Memorie del Reale Istituto Lombardo di Scienze e Lettere. Classe di Scienze Matematiche e Naturali. Vol. xi. Fasc. 1. 1868.

Monthly Microscopical Journal. Nos. 7–9 (July to September), 1869.

W. C. Williamson.—On the Structure and Affinities of some Exogenous Stems from the Coal-measures, 66.
T. P. Barkas. A supposed Mammalian Tooth from the Coal-measures, 104.
W. Thomson.—On *Holtenia*, a Genus of Vitreous Sponges, 107.
W. B. Carpenter.—On the Rhizopodal Fauna of the Deep Sea, 161.

Moscow. Bulletin de la Société Impériale des Naturalistes de Moscou. 1868. No. 3.

Naturalist's Note-Book. Vol. iii. Nos. 31–33. July to September 1869.

C. O. G. Napier.—On the Lowest Lias Beds occurring at Cotham, Bedminster, and Keynsham, near Bristol, 193.

Newcastle-on-Tyne. Natural-History Transactions of Northumberland and Durham. Vol. iii. Part 1. 1869.

G. Rome Hall.—An Enquiry into the Origin of certain Terraced Slopes in North Tynedale, 82 (1 plate).
A. Hancock and T. Atthey.—Notes on various Species of *Ctenodus* obtained from the Shales of the Northumberland Coal-field, 54.
—— ——. Notes on the Remains of some Reptiles and Fishes from the Shales of the Northumberland Coal-field, 66 (3 plates).

New York. Annals of the Lyceum of Natural History of New York. Vol. ix. Nos. 1–4. April 1868.

J. S. Newberry.—Notes on the Later Extinct Floras of North America, with descriptions of new Species of Plants from the Cretaceous and Tertiary strata, 1.

——. State Library. Reports. 1868–69.

——. Annual Report of the Trustees of the Museum of Comparative Zoology. 1866–68.

——. Twentieth Annual Report of the Regents of the University of the State of New York, on the condition of the State Cabinet of Natural History, 1868.

R. P. Whitfield.—On the internal appendages of the Genus *Atrypa*, 141.
Notice of Vol. IV. of the 'Palæontology of New York,' 145.
J. Hall.—Contributions to Palæontology, 169.

Palermo. Giornale di Scienze Naturali ed Economiche, pubblicato per cura del Consiglio di perfezionamento annesso al R. Istituto Tecnico di Palermo. Vol. v. Fasc. 1 & 2. 1869.

G. G. Gemmellaro.—Sulla Fauna del Calcario a *Terebratula janitor* del nord di Sicilia (continuazione), 90 (4 plates).

Paris. Anna lesdes Mines. Tome xv. Livr. 2–3. 1869.

Mussy.—Description de la constitution géologique et des ressources minérales du canton de Vicdessos et spécialement de la mine de Rancié (troisième partie), 327.
Adam.—Tableau minéralogique, 405.

——. Tome xvi. Livr. 4. 1869.

Ville.—Notice sur les gîtes minéraux et les matériaux de construction de l'Algérie, 133.

——. Bulletin de la Société Géologique de France. Deuxième Série. Tome xxvi. No. 2.

Mussy —Roches ophitiques du département de l'Ariége, 81.
Coquand.—Sur les assises qui, dans les Bouches-du-Rhône, sont placées entre l'oxfordien superieur et l'étage valonginien, 100.
Hébert.—Sur les couches comprises, dans le midi de la France, entre les calcaires oxfordiens et les néocomiens marneux à *Belemnites dilatatus*, 131.
Dieulafait.—Sur les calcaires blancs néocomiens des environs de Toulon, 139.
Coquand.—Description géologique de la formation crétacée de la province de Teruel, 144 (plate 1).
Collenot.—Existence de blocs erratiques d'origine glaciaire au pied du Morvan, 173.
Beaudouin.—Sur la *Neritopsis Deslongchampsii*, 182.
Coquand.—Sur la formation crétacée de la montagne de la Clape, 187.

——. Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences. Premier Semestre, 1869. Tome lxviii. Nos. 23–26.

E. de Verneuil.—Note sur l'Attitude de Vésuve le 26 Avril 1869, 1309.

Paris. Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences. Deuxième Semestre 1869. Tome lxix. Nos. 1–10.

A. Damour.—Jakobsite, nouvelle espèce minérale, 168.
C. Gay.—Sur le tremblement de terre arrivé en août 1868 dans l'Amérique méridionale, 260.
— Hébert.—Recherches sur l'âge des grès à combustibles d'Höganás et des grès à végétaux de Hör, 296.
— Poirée.—Sur la différence de niveau supposée autrefois entre la Mer Rouge et la Méditerranée, 321.

Philadelphia. Proceedings of the American Philosophical Society. Vol. x. Nos. 79 & 80. 1868.

E. Miller.—Explanatory Memoir on a series of Photographic Representations of remarkable Rocks on Smoky River, Kansas, 382.
H. D. Vail.—On an Eruption of Mount Vesuvius, 421, 425.
S. F. Peckham.—On the Origin of Bitumens, 445.
F. V. Hayden.—On the Geology of Wyoming, 463.
J. F. Latham.—On subsidence of the Coast, 541.

——. ——. Vol. xi. No. 81. 1869.

E. D. Cope.—On *Mylodon annectens*, 15.
——. On the Cretaceous Tortoises, 16.
F. V. Hayden.—On the Geology of Wyoming, 25.
A. Winchell.—On the Marshall Group, 57.
P. Sheafer.—Boring Records in the Anthracite Region, 107.
E. D. Cope.—On a New Mosasauroid Reptile, 117.

——. Transactions of the American Philosophical Society. New Series. Vol. xiii. Part 3. 1869.

Thomas Evans Blackwell.—On the Hydrology of the Basin of the River St. Lawrence, 249 (2 plates).
J. P. Lesley.—Notes on a Map intended to illustrate five types of Earth-surface in the United States between Cincinnati and the Atlantic, 307 (with a map).
Leo Lesquereux.—On *Fucoides* in the Coal-formations, 313 (1 plate).
James Hall.—Notes upon the Geology of some portions of Minnesota, from St. Paul to the western part of the State, 329.
Horatio C. Wood, Jun.—A Contribution to the knowledge of the Flora of the Coal Period in the United States, 341 (2 plates).
Leo Lesquereux.—On Species of Forest Plants from the Tertiary of the State of Mississippi, 411 (10 plates).

Photographic Society. Journal. Nos. 207–209.

Portland Society of Natural History. Proceedings. Vol. i. Parts 1 & 2. 1862 & 1869.

C. H. Hitchcock.—Notes on the Geology of Maine, 72.
N. T. True.—Grooved Boulders in Bethel, 92.
C. H. Hitchcock.—A new Species of *Carpolithes*, 95.
J. W. Dawson.—Fossil Plants from Perry, Maine, 99 (1 plate).
E. Billings.—Description of some new Species of Fossils, with remarks on others already known, from the Silurian and Devonian Rocks of Maine, 104 (1 plate).

Portland Society of Natural History. Proceedings. Vol. i. Parts 1 & 2 (*continued*).

N. T. True.—New Localities of Minerals in Maine, 163 (1 plate).
——. Mineralogy among the Aborigines of Maine, 165.
J. De Laski.—On the Motion of Glaciers, 168.

Quarterly Journal of Science. No. 23. July 1869.

E. Hull.—On a Ternary Geological Classification, 353 (1 plate).
G. Harkness.—The Prehistoric Antiquities of and around Lough Gur, 388 (1 plate).
Choronicles of Geology and Mineralogy, 438, 450.

Quekett Microscopical Club. Journal. No. 7. July 1869.

J. B. Jordan.—On an improved Apparatus for the Preparation of Rock Sections for Microscopical Examination, 186.

——. Fourth Report. July 1869.

Royal Agricultural Society. Journal. Second Series. Vol. v. Part 2. 1869.

Royal Asiatic Society of Great Britain and Ireland. Journal. New Series. Vol. iv. Part 1. 1869.

Royal Geographical Society. Journal. Vol. xxxviii. 1868.

T. Staley.—On the Geography and Recent Volcanic Eruption of the Sandwich Islands, 361.

——. Proceedings. Vol. xiii. Nos. 3 & 4. 1869.

Royal Institution of Great Britain. Proceedings. Vol. v. Part 6.

W. Carruthers.—The Cryptogamic Forests of the Coal Period, 511.

Royal Society. Proceedings. Vol. xvii. Nos. 112 & 113. 1869.

R. Owen.—On the Molar Teeth, lower Jaw, of *Macrauchenia paradoxa*, Ow., 454.

——. ——. Vol. xviii. No. 114. 1869.

P. M. Duncan and H. M. Jenkins.—On *Palæocoryne*, a Genus of the Tubularine Hydrozoa from the Carboniferous formation, 42.
W. B. Carpenter.—On the Rhizopodal Fauna of the Deep Sea, 62.

St. Petersburg. Bulletin de l'Académie Impériale des Sciences. Tome xiii. Nos. 4 & 5. 1869.

——. Mémoires de l'Académie Impériale des Sciences de St. Pétersbourg. 7me Série. Tome xii. Nos. 4 & 5. 1868.

——. ——. Tome xiii. Nos. 1–7. 1868–69.

Salem. Peabody Academy of Sciences. First Annual Report. 1869.

——. ——. Memoirs. Vol. i. No. 1. March 1869.

Salem. Proceedings of the Essex Institute. Vol. v. Nos. 7 & 8. July and December 1868.

Scientific Opinion. Vol. ii. Nos. 36–48. July to September 1869.

F. W. Holland.—Recent Explorations in the Peninsula of Sinai, 103, 127, 147.
W. Carruthers.—The Cryptogamic Forests of the Coal Period, 123, 149.
Geological Excursion to Hunstanton, 226.

Smithsonian Institution. Annual Report of the Board of Regents for the year 1867. 8vo. Washington, 1868.

Man as the Cotemporary of the Mammoth and the Reindeer in Middle Europe, 335.

——. Smithsonian Miscellaneous Collections. No. 194. Land and Freshwater Shells of North America. Part 1. Pulmonata Geophila. By W. G. Binney and T. Bland. 1869.

Society of Arts. Journal. 115th Session. Nos. 867–879.

Mining Industry in Queensland, 760.
Discovery of Copper in Australia, 826.

Student and Intellectual Observer. Vol. iii. No. 18.

——. Vol. iv. Nos. 19 & 20.

P. M. Duncan.—Corals and their Polypes, 95 (1 plate).
The Great Earthquake of Peru, 1868, 146.
Exploration of Kent's Cavern. Further Report of the Committee of the British Association, 330, 350, 871.
The Recent Earthquake in New Zealand, 332.
Antiquity of Man, 333.

Upsal. Nova Acta Regiæ Societatis Scientiarum Upsaliensis. Vol. viii. 4to. Upsal, 1821. *Presented by Sir Charles Lyell, Bart.*

G. Wahlenberg.—Petrificata Telluris Suecanæ examinata, 1 (4 plates).
——. Additamenta quædam ad Petrificata Telluris Suecanæ, 293.

Vienna. Anzeiger der k.-k. Akademie der Wissenschaften in Wien. 1869. Nos. 15–20.

L. Barissich.—Erdbeben auf Rhodus, 112.
J. Rumpf.—Ueber den Hartit von Oberdorf und den angrenzenden Gebieten von Voitsberg und Köflach in Steiermark, 121.
A. E. Reuss.—Ueber die Bryozoen der Tertiärschichten von Kischenew in Bessarabien, 123.
J. Redtenbacher.—Chemische Analyse der Mineralquellen von Dorna Watra und Pojana negri in der Bukowina, 124.
G. Tschermak.—Chemische Zusammensetzung der Feldspathe, 132.
Jos. Barber.—Chemische Analyse der Jodquelle zu Roy, 137.

——. Verhandlungen der k.-k. geologischen Reichsanstalt. 1869. Nos. 9–11.

G. C. Laube.—Die Echinoiden der österreichisch-ungarischen oberen Tertiärablagerungen, 182.

Vienna. Verhandlungen der k.-k. geologischen Reichsanstalt. 1869. Nos. 9–11 (*continued*).

M. Neumayr.—Beiträge zur Kenntniss tertiärer Binnenfaunen, 184.
— Bauini.—Erdbeben auf Rhodus und Simi, 185.
D. Stur.—Die Braunkohlen-Vorkommnisse im Gebiete der Herrschaft Budafa im Zalaer Comitate in Ungarn, 185.
E. von Mojsisovics.—Salzvorkommen zwischen Lietzen und Aussee, 186.
F. Foetterle.—Die geologischen Verhältnisse der Gegend zwischen Nikopoli, Plewna und Jablanitza in Bulgarien, 187.
H. Wolf.—Das Schwefelvorkommen zwischen Alta-Villa und Tufo, O. N. O. von Neapel, 195.
G. C. Laube.—Trias von Spitzbergen, 208.
B. Mikó.—Die Amphibol-Trachyte des Dr. Jos. Szabó, 208.
M. Gramski.—Ueber das Vorkommen reicher Schwefelantimon-Lager in der Moldau, 209.
F. Foetterle.—Die Gegend zwischen Tissowitza, Orsova, &c., in der Roman-Banater Militärgrenze, 210.
U. Schloenbach.—Die Umgebungen von Pettnik, Mehadika, &c., im Roman-Banater Grenzregimente, 212.
K. M. Paul.—Die Umgebungen von Homonna, 215.
M. Neumayr.—Das Sandstein-Gebiet im östlichen Theil des Unghvarer Comitates, 216.
H. Wolf.—Das Kohlenvorkommen bei Gomodi und das Eisenvorkommen bei Rákó im Tornaer Comitate, 217.
E. von Mojsisovics.—Das Gebiet von Thiersee, Kufstein, &c., in Nordtirol, 220.
J. Szabó.—Die Amphiboltrachyte der Matra in Central-Ungarn, 231.
H. Abich.—Die armenisch-georgischen Trachyte, 232.
C. J. Schultze.—Pseudomorphosen von Brauneisenstein nach Schwefelkies, aus der Umgebung von Osnabrück, 233.
E. Keller.—Das Gebiet am Fusse des Movecz-Berges, 234.
F. von Andrian.—Reisenotizen vom Bosphorus und Mytilene, 235.
T. Petersen.—Ueber die Beziehung des Diabases zu den in der Lahn- und Dillgegend vorkommenden Eisenerzen, &c., 236.
K. Peters.—Schichten der sarmatischen Stufe bei Kirchbach südöstlich von Graz, 239.
G. Stache.—Geologische Verhältnisse der Umgebung von Unghvár, 240.
K. M. Paul.—Die nördlichen Theile des Zempliner und Ungher Comitates, 241.
E. von Mojsisovics.—Das Gebiet von Häring und das Kaisergebirge, 243.
H. Wolf.—Das Eperies-Tokajer Gebirge zwischen Skaros und Herlein, 244.

Vienna. Sitzungsberichte der k.-k. Akademie der Wissenschaften in Wien. Mathematisch-naturwissenschaftliche Classe. Band lvii. Abth. i. Hefte 4 & 5. April and May 1869.

A. Boué.—Ueber die jetzige Theilung der wissenschaftlichen Arbeit, sowie über Granit und Metamorphismus-Theorien, 557.
K. F. Peters und R. Maly.—Ueber den Staurolith von St. Radegrund, 646 (1 plate).
G. C. Laube.—Die Fauna der Schichten von St. Cassian, iv. Abth. Gastropoden, ii. Hälfte, 661.
M. von Zepharovich.—Mineralogische Mittheilungen, iii., 740.

Vienna. Sitzungsberichte der k.-k. Akademie der Wissenschaften in Wien. Mathematisch-naturwissenschaftliche Classe. Band lvii. Abth. i. Hefte 4 & 5 (*continued*).

K. F. Peters.—Zur Kenntniss der Wirbelthiere aus den Miocänschichten von Eibiswald in Steiermark, ii., 756.
E. Suess.—Ueber die Aequivalente des Rothliegenden in den Südalpen (Schluss), 763 (1 plate).
C. von Ettingshausen.—Die Fossile Flora der älteren Braunkohlenformation der Wetterau, 807 (5 plates).
F. Pošepný.—Ueber concentrisch-schalige Mineralbildungen, 894 (2 plates).

——. ——. ——. Band lvii. Abth. ii. Hefte 4 & 5, and Band lviii. Abth. ii. Heft 1. April to June 1869.

Warwickshire Naturalists' and Archæologists' Field-club. Thirty-third Annual Report. April 1869.

——. Proceedings. 1868.

P. B. Brodie.—Sketch of the Lias generally in England, and of the Insect and Saurian beds, 1.

Woolhope Naturalists' Field-club. Transactions, 1868. 8vo. Hereford, 1869.

Dr. Bull.—The Silurian Fossils at Wicton, 3.
Dr. M'Cullough.—The Cornstones of Herefordshire and Monmouthshire, 8.
G. P. Bevan.—The South Wales Coal-field, 35.
— Adams.—Fossils from the South Wales Coal-field, 46.
W. S. Symonds.—On the Geology of the District of Penwyllet and Scwd Hen Rhyd, 68.
P. B. Brodie.—Palæontological Notes from Woolhope, 144.
J. W. Salter.—Notes on the Onny River Section, 148.
——. Fossils illustrated and described, 239.
J. D. Latouche.—Alluvial Deposits of Rivers, 249.

Zoological Society. Proceedings. 1869. Part 1.

——. Transactions. Vol. vi. Part 8. 1869.

II. PERIODICALS PURCHASED FOR THE LIBRARY.

Annales des Sciences Naturelles. Zoologie et Paléontologie. 5e Série. Tome xi. Nos. 3–5. 1869.

Annals and Magazine of Natural History. Fourth Series. Vol. iv. Nos. 19–21. July to September 1869.

E. Billings.—On the Structure of the Blastoidea, 76.
O. Heer.—The last Discoveries in the extreme North, 81.
Grand' Eury.—Observations on the Calamites and Asterophyllites, 124.

Annals and Magazine of Natural History. Fourth Series. Vol. iv. Nos. 19–21 (*continued*).

A. Milne-Edwards.—On the Ancient Fauna of the Mascarene Islands, 129.

A. Hancock and T. Atthey.—On a new Labyrinthodont Amphibian from the Northumberland Coal-field, and on the occurrence in the same locality of *Anthracosaurus Russelli*, 182.

Journal de Conchyliologie. 3e Série. Tome ix. Nos. 3 & 4. 1869.

L'Institut. 1re Section. 37e Année. Nos. 1848–1865.

Palæontographica: herausgegeben von Dr. W. Dunker. Vol. xvi. Lief. 7. April 1869.

O. Speyer.—Die Conchylien der Casseler Tertiärbildungen, 297 (5 plates).

——: herausgegeben von Dr. W. Dunker und Dr. K. A. Zittel. Vol. xvii. Lief. 3. August 1869.

R. Ludwig.—Fossile Pflanzenreste aus den paläolithischen Formationen der Umgegend von Dillenburg, &c., 105 (11 plates).

——. Korallenstöcke aus paläolithischen Formationen, 129 (2 plates).

——: ——. Vol. xix. Lief. 1. June 1869.

A. Schenk.—Beiträge zur Flora der Vorwelt, 1 (7 plates).

III. GEOLOGICAL AND MISCELLANEOUS BOOKS.

Names of Donors in Italics.

Anon. India. Mineral Statistics, Coal. 8vo.

Anon. (*Research*). The True Theory of the Earth, and Philosophy of the Predicted End. 8vo. Edinburgh, 1869.

Bauerman, H. Note on the new deep Adit in the Upper Harz Mines. 8vo.

Boccardo, Gerolamo. Sismopirologia. Terremoti, Vulcani, e lente Oscillazioni del Suolo, saggio di una Teoria di Geografia fisica. Small 8vo. Genoa, 1869. *Presented by Charles Darwin, Esq., F.R.S.*

Brodie, P. B. A Sketch of the Lias generally in England, and of the "Insect and Saurian Beds." 8vo. 1868.

Capanema, G. S. Apontamentos Geologicos (ao Correr da Penna). Rio de Janeiro, 1868.

Ciofalo, Saverio. Descrizione della *Natica Gemmellaroi*, nuova Specie del Cretaceo superiore dei dintorni di Termini-Imerese. (Palermo?) 1869.

Credner, Hermann. Die vorsilurischen Gebilde der oberen Halbinsel von Michigan in Nord-Amerika. 8vo. 1869.

Commissioners of Fisheries of the State of Maine. Reports for 1867 and 1868. Augusta, 1869.

D'Ancona, Cesare. Sulle Neritine Fossile dei Terreni Terziari Superiori dell' Italia Centrale. 8vo. Pisa, 1869.

Dawson, W. J. Modern Ideas of Derivation. 1869.

Davidson, Thomas. Notes on Continental Geology and Palæontology. Parts 1–4. 8vo. 1869.

——. Notes on some Recent Mediterranean Species of Brachiopoda. 8vo. 1869.

Ehrenberg, C. G. Ueber mächtige Gebirgsschichten vorherrschend aus mikroskopischen Bacillarien unter und bei der Stadt Mexiko. 4to. 1869.

Erioni, Antonio. Sugli Ittio-fito-schisti Miocenici presso le Miniere zolfifere della Sicilia. 4to. Caltanissetta, 1869.

Fisher, O. On the Elevation of Mountains by Lateral Pressure, its Cause, and the Amount of it, with a Speculation on the Origin of Volcanic action. 1869.

Geological Survey of New Zealand. Third Annual Report on the Colonial Museum and Laboratory. By James Hector. 8vo. Wellington, N. Z. 1868.

Geologische Specialkarte des Grossherzogthums Hessen: Section Lauterbach, geologisch aufgenommen von H. Tasche und W. C. J. Gutberlet, nach deren Tode durchgesehen und mit Zusätzen vermehrt von Rudolph Ludwig. (Map and explanation.) Darmstadt, 1869. *From the Geological Society of the Middle Rhine.*

Grewingk, C. Ueber Eisschiebungen am Wörzjärw-See in Livland. 8vo. Dorpat, 1869.

Harris, T. W. Entomological Correspondence. 8vo. 1869. *Presented by the Boston Society of Natural History.*

Hector, James. Meteorological Report for 1868. New Zealand, 1869.

Jervis, W. Guida alle Acque Minerali d'Italia. 8vo. Turin, 1868.

Jerwood, James. On the Application of Weight to test the Figure of the Earth. 8vo. 1869.

Karrer, F., und T. Fuchs. Geologische Studien in den Tertiärbildungen des Wiener Beckens. 1869.

Kokscharow, N. von. Materialien zur Mineralogie Russlands. Band V. (Schluss). 8vo. St. Petersburg, 1869.

Lea, Isaac. Observations on the Genus *Unio,* together with Descriptions of New Species in the Family Unionidæ, and descriptions of New Species of the Melanidæ and Paludinæ. Vol. xii. 4to. Philadelphia, 1868.

Lehigh Coal and Navigation Company. Report of the Board of Managers. Philadelphia, 1869.

Leitner, G. W. Results of Tour in Dardistan, Kashmir, Little Tibet, Ladak, Zanskar, &c. Vol. i. Part 1.

Letter of the President of the National Academy of Sciences, on the Operations of that Society for the past year. 1868. *From the National Academy of Sciences* (Washington, U. S.).

Letter of the Vice-President of the National Academy of Sciences, on the Proceedings of the Academy during the year 1866. *From the National Academy of Sciences* (Washington, U. S.).

Linnarsson, J. G. O. On some Fossils found in the Eophyton Sandstone at Lugnås in Sweden. 8vo. Stockholm, 1869.

Login, T. Roads, Railways, and Canals for India. 8vo. London, 1869.

Ludwig, Rudolph. Versuch einer Statistik des Grossherzogthums Hessen auf Grundlage der Bodenbeschaffenheit. 8vo. Darmstadt, 1868.

Lütken, C. F. Additamenta ad Historiam Ophiuridarum. Tredie Afdeling. 1869.

Lyman, B. S. Against the supposed former Plasticity of the Puddingstone Pebbles of Purgatory, Rhode Island. 8vo. *Presented by Prof. A. Winchell.*

——. On the Link of Gunter's Chain as the Unit of a Decimal System of Weights and Measures. 8vo. *From Prof. A. Winchell.*

Marsh, O. C. Description of a New Species of *Protichnites* from the Potsdam Sandstone of New York.

Merian, Peter. Geognostische Uebersicht des südlichen Schwarzwaldes. Small 8vo. Basel, 1832. *Presented by Sir Charles Lyell, Bart.*

Merian, Peter. Ueber die Grenze zwischen Jura- und Kreideformation. 8vo. Basel, 1868.

Morris, John. Lead-bearing Districts of the North of England. 8vo. London, 1869.

Pourtales, L. F. de. Contributions to the Fauna of the Gulf Stream at great Depths (2nd series).

Proceedings of the American Association for the Advancement of Science. Sixth Meeting, 1851. 8vo. Washington, 1852. *Presented by Sir Charles Lyell, Bart.*

Ramsay, A. Supplement to the English Cyclopædia: Natural History. Parts 1–6. 1869.

Report of the Government Astronomer upon the Proceedings of the Observatory, in connexion with the total Eclipse of the Sun on August 18th, 1868. *Presented by the Secretary of State for India.*

Report of the Commissioner of Agriculture for the year 1867. 8vo. Washington, 1868. *Presented by the (U. S.) Commissioner of Agriculture.*

Reports of the Inspectors of Mines for the year 1867. *Presented by H. M. Government.*

Report of the Royal Commissioners on Water-Supply. 1869. *Presented by J. Prestwich, Esq., F.R.S.*

Reuss, A. E. Zur fossilen Fauna der Oligocänschichten von Gaas. 1869.

Rigaux, A., et E. Sauvage. Description de quelques espèces nouvelles de l'étage Bathonien du Bas Boulonnais. 8vo. Boulogne, 1868.

Rütimeyer, L. Ueber Thal- und See-Bildung. Beiträge zum Verständniss der Oberfläche der Schweiz. 4to. Basel, 1869.

Sain Gon (*E. St. John Fairman*). Ghirghis Mahomed, or Reports of the New Egyptian Parliament (1st Session). 8vo. (Jericho!) 1867.

Sauvage, Emile. Considérations sur les Poissons Fossiles. 8vo. 1869.

Senft, Ferdinand. Der Steinschutt und Erdboden nach Bildung, Bestand, Eigenschaften, Veränderungen und Verhalten zum Pflanzenleben. 8vo. Berlin, 1867. *Presented by Sir Charles Lyell, Bart.*

Smyth, R. B. The Gold Fields and Mineral Districts of Victoria. 4to. 1869.

Tate, George. The Geology, Botany, and Zoology of the Neighbourhood of Alnwick. 8vo. Alnwick, 1869.

Tate, Ralph. Appendix to the Manual of Mollusca of S. P. Woodward. 12mo. London, 1868.

Tschermak, G. Mikroskopische Unterscheidung der Mineralien aus der Augit-, Amphibol-, und Biotitgruppe. 1869.

——. Die Porphyrgesteine Oesterreichs aus der mittleren geologischen Epoche. 1869.

Williamson, W. C. On the Structure of the Woody Zone of an undescribed form of Calamite. 8vo. London, 1869.

Wilson, A., T. Login, and G. Higgin. Irrigation in India and in Spain. Edited by James Forrest. 8vo. London, 1869. *Presented by T. Login, Esq.*

Winchell, A. Appendix to a Report on the Grand Traverse Region. 8vo. 1866.

——. A Report on the Geological and Industrial Resources of the Counties of Antrim, Grand Traverse, Benzie, and Leelanaw in the Lower Peninsula of Michigan. 8vo. Ann Arbor, 1866.

——. Man the last term of the Organic Series. 8vo. Ann Arbor, 1867.

——. Statement of operations in the Museum of the University of Michigan, in the Department of "Geology, Zoology, and Botany" and the Department of "Archæology and Relics" for the year ending September 24th, 1868.

——. The Onward March of the Race.

——. The Fruit-bearing Belt of Michigan. 8vo.

——. Stromatoporidæ: their Structure and Zoological Affinities. 8vo.

Zirkel, Ferdinand. Leucitgesteine im Erzgebirge. 8vo.

IV. BOOKS PURCHASED FOR THE LIBRARY.

Canterbury Gas and Water. New Water Supply. Report from the Engineer (*S. C. Homersham*). 8vo. 1869.

Lyell, Sir Charles. Principles of Geology. 10th edition. 2 vols. London, 1868. (Second Copy.)

Milne-Edwards, A. Recherches Anatomiques et Paléontologiques pour servir à l'Histoire des Oiseaux Fossiles. Livraisons 26–30.

Ooster, W. A., und C. von Fischer. Protozoe Helvetica. Band I. 4to. 1869.

Paléontologie Française. Terrain Jurassique. Livraisons 16–18. 1869.

Quenstedt, F. A. Petrefactenkunde Deutschlands. I. Abth. Band II. Heft 3, with Atlas. 1869.

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

December 22, 1869.

John Hopkinson, Esq., of 8 Lawn Road, Haverstock Hill, N.; Samuel John Sanders, Esq., M.A., Vice-Master of the Beds. Middle-Class Public School; and Jabez Church, Esq., C.E., of 17 B Great George Street, Westminster, S.W., and Chelmsford, Essex, were elected Fellows of the Society.

The following communications were read:—

1. *On the* Iron-ores *associated with the* Basalts *of the* North-east *of* Ireland. By Ralph Tate, Esq., Assoc. Linn. Soc., F.G.S., *and* John Sinclair Holden, M.D., F.G.S.

Contents.

The recent development of a new branch of mining industry in the north of Ireland has given us ample facilities for ascertaining the

nature and geognostic relations of the iron-ores associated with the basalts, and the present seems a fitting occasion to submit to the Geological Society the results of our observations.

The occurrence of ferruginous ochres in the midst of the basalt of the Giant's Causeway was pointed out at an early period by the Rev. Dr. Hamilton*, and has been noticed by subsequent writers on the geology of the County Antrim. Dr. Hamilton, in his section of the Pleaskin, represents "a thin course of iron-ore amid a bed of ochre;" and it is to beds of this character that we would now direct attention; for beyond the mere record of the occurrence of an iron band in the basalt of the Giant's Causeway, no further account of this phenomenon has been brought before the notice of geologists.

The railway-cutting at Ballypalidy, near Templepatrick, exposed an extensive ochreous mass, the working of which was commenced by Dr. Ritchie, of Belfast, in 1861; but within the last three years new and richer deposits have been discovered and worked in other parts of the county. A list of the localities where operations are now carried on will be found appended. Shortly after the discovery of the ferruginous beds at Ballypalidy, our attention was directed to the nature of the ore there; and in the spring of 1868 one of us communicated to the Belfast Naturalists' Field Club an abstract of this paper in part, which is published in that Society's Proceedings for that year.

We may be allowed to state that the examination of these iron-ores, the subject of the present communication, has been undertaken solely in the interest of science. And we would record our obligations to the Earl of Antrim, Dr. Ritchie, and Mr. T. Fisher for permission to inspect the mines respectively worked by them, and for statistics of produce relating to the same, also to Dr. Apjohn and Professor Hodges for analyses of basalt and iron-ores.

II. Petrology of the Iron-ores and associated Rocks.

As regards the origin of their present condition, the iron-ores may be divided into two groups; to the one belongs the ore of Ballypalidy, whilst all the others known to us are included in the second group. The former is of sedimentary origin, but the latter are the direct products of metamorphic agencies.

As a remarkable similarity is exhibited by all the sections of the iron-ores of the second group and their associated rock-masses, it will be unnecessary to describe each of them; we select, therefore, for illustration the following, which are the most instructive of the series.

1. *Section on Slievananee.*—On the south slope of Slievananee mountain, situated 6 miles from Cushendall, on the road to Ballymena, a rich mine of iron-ore was opened three years ago beneath the basalt, at an elevation of 1095 feet above the sea, and 687 feet vertically below the summit of the mountain. The present face of the workings presents a horizontal section of nearly half a mile; the

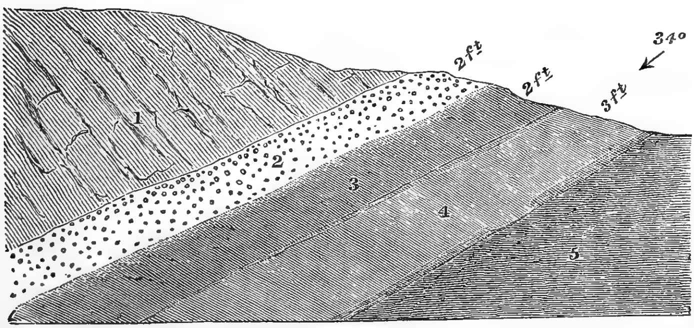
* Natural History of the Basaltes and its attendant Fossils in the Northern Counties of Ireland, 1790.

iron band is seen gently undulating, and is traceable for a further distance of a mile in both an easterly and westerly direction. The "mineral" is mined by approximately level drifts, running N. 40° E. and at right angles to the face of the workings; many of the levels have reached to a distance of two hundred yards.

The following section is in descending order, numbered from above:—

1. *Hard, compact, columnar basalt.* Where exposed to weathering influences, it is decomposed at the lower surface for a foot or so, within which there is an argillaceous mineral, probably a magnesian clay, termed by the miners "rock-grease."
2. *Pisolitic iron-ore.* This band consists of a dense red ochreous paste, with included spheroids, composed chiefly of a mixture of magnetite and red hæmatite. In the upper part of the band the spheroids are occasionally as large as hazel nuts, but more frequently of the size of peas, and densely crowded. The size and frequency of the nodules diminish downwards; .... Thickness 2 ft.–2 ft. 6 in. and the ore passes into
3. *Indurated ferruginous ochre,* of a reddish-yellow colour, breaking up into irregular lumps. .... Thickness 4 ft. It merges insensibly into the underlying band of
4. *Lithomarge.* A variegated rock, with a predominating blue colour and greasy feel, breaking up into small sub-spheroidal blocks. The whole mass might readily be mistaken from a distance for some of the variegated marls of the Keuper series .... Thickness 25 ft.
5. The lithomarge graduates downwards into a basalt exhibiting a concretionary structure, the outer coats not distinguishable from the lithomarge, while the kernel is a compact basalt.

Fig. 1.—*Section at Belumford.*



2. *Section at Belumford,* north-west extremity of Island Magee:—

1. *Columnar basalt,* with two or three inches of decomposed rock below.
2. *Pisolitic Iron-ore.* The upper two inches with little or no ochreous matrix: the spheroids large, and now and then a thin lamina of the ore. The ochre increases in quantity with the increase of depth, and the iron-ore merges into 'bole' .... Thickness 2 ft. 6 in.

3. *Bole*—an indurated red ferruginous ochre, less compact than that of Slievananee, ... Thickness 2 ft. passing into and alternating with
4. *Yellow Ochre*,.. Thickness 3 ft. which graduates into
5. *Blue Lithomarge*. Base not seen, but thickness proved to 29 ft. 6 in.

The several masses in the above section, as, indeed, in others, exhibit a pseudo-stratified arrangement, here dipping at an angle of 34°, E. 50° N. magnetic. The whole mass has been bored to a depth of 45 feet, which gives a minimum thickness for the iron ore, ochres, and lithomarge of $37\frac{1}{3}$ feet.

3. *Enumeration of localities.*—Passing east from Slievananee, the iron-beds are worked from the face of the basaltic escarpment overhanging Milltown, Red Bay, at the entrance to Glenariff Glen; the beds dip west about 5°, and are about 200 feet above the upper limit of the White Limestone. Further to the east, the iron-band has been traced to near Garron Point.

Two miles to the west of Carnlough, the ferruginous series is seen at a height of 600 feet above the sea-level, dipping at an angle of about 40° east (magnetic). The matrix of the pisolitic ore, 22 inches in thickness, is of a bright vermilion-red colour, becoming browner as it passes downward; it then passes into a friable yellowish ochre, four and a half feet thick, which, in its turn, graduates into a blue lithomarge, 35 feet thick. Overlying the pisolitic ore is a semiprismatic basalt, the columns of which are perpendicular, and consequently include, with the underlying strata, an angle of 50°.

Other outcrops are worked at Ballyvaddy and Tully, near Glenarm, andat Anteville, Kilwaughter (3 mines), and Shane's Hill (2 mines), near Larne.

4. *Deductions from the several sections.*—We deduce from the foregoing sections the gradual passage of the underlying basalt into a variegated lithomarge of an average thickness of 30 feet, graduating insensibly into the overlying red or yellow ochre or bole, 5 to 6 feet thick, which passes into, and is surmounted by, a pisolitic iron-ore of an average thickness of two feet. The spheroids of iron-ore increase in number and size towards the upper part, and not unfrequently constitute that portion of the bed. The line of junction between the iron-band and the overlying basalt (which is usually more or less columnar), is well defined, and in a few instances exhibits decided unconformability.

Though a band of iron-ore can be traced with some certainty over a considerable area, yet it is by no means proved that the ore in the various sections, many of which are several miles distant from each other, represents portions of one sheet extending uniformly throughout the basalt. To determine this point will require a laborious survey of the country, chiefly because of the numerous faults—a task too gigantic for us to perform. Still we are justified, from the identity of the phenomena in the many sections examined, in assuming that in the midst of the basaltic rocks there is a continuous band of iron-ore.

Only in two instances have we been able to refer the iron-band

to its position relatively to that of the underlying White Limestone—which, by the way, is of varying thickness, and that often within very limited distances. At Red Bay the iron-ore is about 200 feet above the upper line of the White Limestone, whilst at Galboly, two miles to the east, in the direction in which the White Limestone thickens, it is about 300 feet vertically above that formation.

III. Origin of the Pisolitic Iron-ore.

1. *Suggested Theories.*—Four theories may be suggested to account for the origin of the iron-ore; these are :—

(1) *Sedimentary theory*, which implies a derivative origin, but is at variance with the petrological features—the distribution of the mineral particles has evidently been regulated by some other force than that of gravity. Mr. Du Noyer, in a paper on the Geology of Island Magee, read before the Natural-History and Philosophical Society of Belfast, November 25, 1868, endeavoured to demonstrate that the iron-ore in the basalt of Island Magee was entirely due to the action of water, "that it was as true an aqueous conglomerate as if it had been found in the heart of the Old Red Sandstone." From this opinion we most emphatically dissent, though at the same time we fully concur with him when he assigns such an origin to the iron beds at Ballypalidy.

(2) *Theory of Deposition*, implying either a precipitation of the ferruginous material from chemical solution, or segregation by organic agency. We believe that the state of combination of the oxides of iron, the intimate structure of the spheroids, and the petrology necessitate some other explanation.

(3) *Igneous theory*, implying production by direct volcanic action. Though specular iron is enumerated among the minerals emitted from active volcanoes, and magnetite and iron pyrites are accessory constituents of several of the basaltic strata, yet such an origin does not meet the requirements of the case in point. The distribution of the spheroids of pisolitic ore demands either a shower of the ferrous nodules over a large area, the smaller ones falling before the larger, or a flow of volcanic mud with suspended spheroids, the smaller sinking first in the mass—both assumptions being highly improbable.

(4) *Metamorphic theory.*—It is only by metamorphism that all the phenomena connected with the pisolitic ore can be interpreted. By metamorphism we understand something more than the effects of heat, and employ the term in its widest significance. We will now proceed to point out what appear to have been the several stages of metamorphic action by which the pisolitic ore has been elaborated out of basalt.

2. *Origin of Bole and Lithomarge.*—There can be no doubt that the lithomarge and bole alternating with compact basalts are but decomposed basalts. The passage from basalt to lithomarge and bole can be traced in all cases; not unfrequently large masses of basalt are to be seen in the midst of the lithomarge, the concentric layers presenting all the varieties of texture and colour between

the hard and black basalt of the interior and the purple or yellowish argillaceous masses in which the basalt appears to be imbedded. Again, the boles often contain cavities filled with the ordinary zeolites of the amygdaloid basalts. Portlock* gives an analogous case of the production of ochre from an allied rock. "The greenstone in the Glenrandal river in Upper Cumber," he says, "is so highly charged with iron as to disintegrate into extensive beds of a very rich ochre. The ochre is sometimes in the state of hydrate and yellow, and at other times red. The mode of alternation is:—felspathic mica-schist, or gneiss, compact below, but quite rotten and decomposed at the top; ochre graduating into a decomposing greenstone. * * * * The greenstone also occurs within the ochre, and by its decomposition gradually merges into it. * * * In a branch stream to the west, the ochre is met with alternating with less altered greenstone, the thickness of the greenstone being 26 feet, and of the ochre 18 feet. And in the townland of Aughlish, in Banagher, it is upwards of 50 feet thick, several patches of greenstone within the mass being still solid, and merging into ochre."

Observations in the field and the following comparative analyses go far to prove that the bole and lithomarge are the resultants of aqueous action in combination with acidulated gases, which, dissolving out certain mineral substances, has effected the decomposition of the basalts, especially the more felspathic ones.

Table of Analyses of Basalt, Lithomarge, and Bole.

	I. Bas.	II. Bas.	III. Lith.	IV. Och.	V. Bole.
Silica	39·72	53·70	49·75	56·40	30·88
Alumina	14·32	25 41	29·88	3·46	20·76
Peroxide of iron	27·87	8·95	6·61	24·14	26·16
Lime	4·15	4·55	0·43	0·90	2·60
Magnesia	4.00	......	1·47	......	......
Sulphuret of iron	......	tr.	......	......	......
Soda	} 9·94	......	......	......	......
Potash		......	6·35	15·10	......
Water		4·30	4·48	......	19·60

I. *Basalt,* Slieve Gallion (Dr. Apjohn). II. *Basalt,* Antrim (Prof. Hodges). III. *Lithomarge,* Germany. IV. *Ochre* of the Basalt, Drumrankin, near Ballymena (Dr. Apjohn). V. *Bole,* Germany.

The chief differences in the chemical composition of bole, lithomarge, and basalt are the increased percentage of peroxide of iron and water, and the less quantity of alkalies in the boles and lithomarges as compared with the basalt.

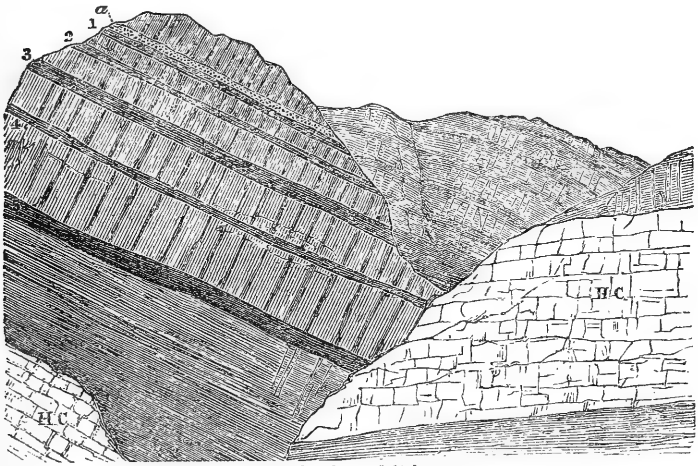
The alternation of basalts and boles indicates successive lava-flows of the more easily decomposed and the crystalline materials, the former having subsequently disintegrated into bole or lithomarge, while the latter has persisted tolerably well. In those instances where there is a passage from the hard rock below to the soft, and from the soft to the hard above, the basalts overlying and underlying

* Geol. Survey, Derry, p. 173.

the bole have been ejected in rapid succession, the decomposition of the intervening volcanic flow being subsequent to the eruption of the superimposed rock; or, in cases where the bole has been indurated, if such do occur, the decomposition of the original rock was effected before the subsequent volcanic outburst; but as these effects were limited to simple induration, except in the case of the production of the pisolitic iron-ore, hereafter to be mentioned, it is extremely probable that these eruptions were subaqueous.

3. *Absence of Boles above the horizon of the Iron-ore.*—Though boles and lithomarges unaccompanied by an iron-ore occur below the iron-ore series, yet no such beds have been met with above the pisolitic ore, though many hundred feet of basalt have been examined.

Fig. 2.—*Section of Galboly Mountain.*



1, 2, 3, 4, 5. Beds of bole and lithomarge.
a. Pisolitic iron-ore. H C. Hard chalk.

On the face of the Galboly mountain three hundred feet of basalt intervene between the pisolitic ore and the White Limestone; and four masses of lithomarge and bole are seen within that thickness, underlying different basaltic terraces (see fig. 2). A similar interstratification is also seen at Slievananee, below the section given at p. 153.

The section of Cape Pleaskin presents five thin strata of ochre below the iron-band, and unassociated with iron-ore, in the lower 180 feet; while that portion of the basaltic escarpment (of the thickness of 172 feet) above the iron stratum does not exhibit a single ochre-bed.

A section at Carnowry, Rock Head, given by Portlock*, shows three thin beds of ochre or bole in a thickness of basalt above the

* *Loc. cit.* p. 142.

hard chalk of 125·5 feet, the remaining 78 feet of basalt being hard, compact, and columnar. No iron-ore is exhibited in this series.

4. *Metamorphism of Bole, and origin of the Pisolitic ore.*—The spheroids of iron-ore are powerfully attracted by the magnet; and the following analysis by Dr. Apjohn proves that the iron is in the states of per- and protoxides. The source of the iron is to be sought for in the hydrous peroxide of the bole, originally in combination with the silicated minerals of the basalt, and probably also in the hydrous oxide resulting from the decomposition of included magnetite and iron pyrites.

Analysis of Spheroids from Pisolitic ore, Red Bay.

Magnetic oxide of iron	11·74
Peroxide of iron	51·37
Silica, alumina, &c. (by diff.)	36·89
	100·00
Percentage of metallic iron	44·45

If we compare the analyses of basalt and ochre (given on p. 156), with those of the iron-ores (p. 159), we shall not fail to notice the general similarity between them; the chief differences observable are the proportions of the several constituents, and, in the case of the pisolitic iron-ore, the different degrees of oxidization of the iron. But these differences do not militate against the presumed origin of the bole and iron-ore—that they are several stages in the metamorphism of one original mass: the addition of water to the basalt, and loss of lime, other alkaline earths, and alkalies, produced bole; the loss of water and oxygen from the ferruginous materials of the bole resulted in an increased percentage of iron in the pisolitic ore. Though aqueous agency may have effected the first change, it could not have produced the second; and heat is the force we must call to our aid in the alteration and concentration of the oxides of iron; and by it the phenomena exhibited by the iron-band are then easy of explanation. We assume that the underlying bole or ochre was a wet or sodden terrestrial surface; in fact many circumstances necessitate such a condition; and the subsequent overflow of basalt effected, by its heat, pressure, and possibly evolved gases, a reduction of the contained oxides of iron into the more concentrated form in which they occur in the iron-band, the aggregation of the ferruginous particles being a result of the same action *. This metamorphism is analogous to the development of new minerals by the intrusion of igneous masses among schistose and stratified rocks. It will be observed that the accumulation of the oxides of iron to certain centres diminishes as we recede from the exciting cause.

* Since the reading of this paper before the Society, we have examined a large number of the spheroids from the pisolitic bed, but once only found diatoms of the *Coscinodiscus* type, and not of the genera which form the bog-ore: they might have got there accidentally.

Table of Analyses of Pisolitic Ores.

Constituents.	I. Kilwaughter.	II. Tully.	III. Red Bay.	IV. Red Bay.	V. Slievananee.	VI. Slievananee.
Peroxide of iron	45·00	45·50	59·40	77·22	71·00	81·50
Protoxide of iron	...	...	......	...	18·00	...
Oxide of manganese	tr.	tr.	......	...	tr.	2·57
Titanic acid	...	2·00	...	tr.	...	tr.
Vanadic acid	...	...				
Alumina, soluble in acids	...	3·00	2·80	...	...	4·20
	36·44	...				
Alumina, insoluble	...	32·50				
Silica, insoluble	...	3·50	10·40	20·65	9·00	8·50
Silica, soluble	...	0·50				
Magnesia	2.44	...	......	...	...	...
Lime	0·56	0·35	......	...	...	·93
Water of combination	18·00	12·65	8·40	2·13	...	1·96
Percentage of metallic iron	31·50	31·85	41·58	54·05	63·70	65·20
Analyst	J. Cameron.	J. Cameron.	Dr. Apjohn.	J. Cameron.	J. Cameron.	Pf. Hodges.

The above analyses are of specimens selected as fair samples of the iron-ores; the great variation is in a great measure accounted for from the samples having been taken from different parts of the iron-band. Numbers I and II. are of a mixed character, the others containing a greater percentage of iron according to the predominance of the spheroids.

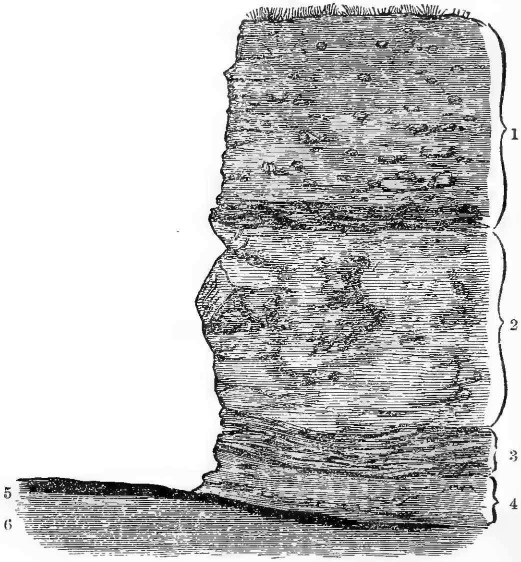
IV. Nature and Origin of the Ferruginous Series at Ballypalidy.

1. *Section at Ballypalidy.*—The iron ochres of Ballypalidy, which are undoubtedly of sedimentary origin, will next occupy our attention. Though references have been made to a section of the iron-ore series at this locality in the pages of Society's Journal *, yet we are constrained to submit further observations on the succession of the beds there exhibited, inasmuch as incorrect impressions regarding the true relationship of the ores to the red bole or ochre-bed and to the lithomarge will be formed from a perusal of the sequence of the beds as given by the author of the paper referred to. Thus, in the section given on p. 358, the beds are enumerated in ascending (and not descending) order; and at p. 361, the plant-remains are stated to occur in the red bole; and, again, Mr. Du Noyer, in a paper read

* Vol. xxv. p. 357: W. H. Baily, "Plant-remains from beds interstratified with the Basalt."

before the Belfast Natural-History and Philosophical Society, states "that the plant impressions are in the red earth or lithomarge lying on and in this hæmatite-conglomerate." These are inaccuracies, and imply that the plants are associated with masses which are the products of metamorphism.

Fig. 3.—*Section at Ballypalidy.*



The section at Ballypalidy, west side of railway (fig. 3), in descending order is as follows:—

1.	Glacial Drift	12 feet.
2.	Conglomerate-bed, composed principally of spheroids of iron-ore, in a ferrugineo-argillaceous paste, with which are associated fragments of basalt and greenstone. Occasionally thin bands of an arenaceous clay with plant-impressions appear among the conglomerate; otherwise there is no appearance of stratification in this bed	10–12 feet.
3.	Plant-bed, a reddish-yellow ferrugineo-arenaceous shale, distinctly laminated, with fragments of plants along the planes of bedding	4–8 inches.
4.	The so-called plant-bed passes into a browner stratum, more argillaceous, the darker colour being due chiefly to an admixture of finely disseminated carbonized vegetable fragments. Plant-remains occur also in it; and patches of lignite increase in frequency downwards. Total thickness of plant-layer and this bed	3 feet.
5.	Lignite	1 foot.
6.	Amygdaloidal basalt.	

The conglomerate is of irregular thickness, thinning out towards the S. W., whilst the finer sediments below increase slightly in

thickness in the same direction. Wherever a fine sediment occurs, even though in the conglomerate, plant-remains are present.

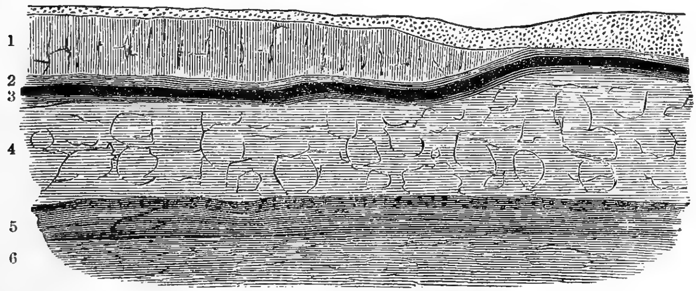
The plant-layer, which is mined and used as a flux, is of low specific gravity, and is not sufficiently rich in iron to be valuable for smelting. The following analysis of this rock is communicated by Dr. J. Apjohn.

Water	25·78
Silica with a little alumina	36·40
Peroxide of iron	9·12
Alumina and other oxides (by difference)	28·70
	100·00
Percentage of metallic iron	6·36

In a neighbouring pit on the N.E. side of the line of railway there is exhibited a similar section. The conglomerate-bed presents a maximum thickness of 10 feet, thinning away to the N.E., and with the underlying shales dipping in the contrary direction. The shales are about 6 feet thick and are underlain by lignite, which surmounts an amygdaloidal basalt.

2. *Relation of the Strata to the Basalts.*—The railway-cutting about a quarter of a mile to the N.E. of the ochre-pits presents a section (fig. 4), which enabled us to place the fore-mentioned sedimentary ores, shales, and lignite in juxtaposition with a subsequent basaltic flow (1).

Fig. 4.—*Section in Ballypalidy Railway-cutting, north side.*



A thin band of impure lignite (3), with or without a clay band below containing plant-remains, and always accompanied by an overlying stratum of clay (2), is seen in one place following the undulating line of the upper surface of a concretionary basalt (4), which latter is superimposed upon a ferruginous series of iron-ore and the underlying bole (5) and lithomarge (6). Elsewhere the basalt above the pisolitic iron has been eroded, and the lignite series rests upon the pisolitic iron-ore or inferior basalt.

The continuity of the lignite-band of these sections with that of the underlying plant-beds and conglomerates in the pits some little distance to the west, is not traceable step by step; but there is little doubt that the several portions visible are parts of one stratum.

3. *Origin of the Ore.*—The mode of occurrence of the conglomerate bed of iron-ore and the associated strata clearly demonstrates a sedimentary origin. The lignite has been derived from a plant-growth *in situ*, upon an eroded surface of basalt. The shaly beds have originated in the tranquil deposition of argillaceous and arenaceous materials mingled with some ferruginous matter, all derived from the degradation of basaltic rocks in the immediate vicinity. The presence of fragments of plants, chiefly leaves and small branches (for rarely do we find large pieces of wood), points to the growth of a terrestrial vegetation near the margins of a morass, or sheet of water, probably a lake. The finely laminated structure of the strata and the delicate nature of the parts of the plants preserved require a tranquil accumulation by aqueous agency.

The conglomerate-bed results from the degradation of the pisolitic iron-ore, of which it is chiefly reconstructed, and of the underlying ochres: it appears to have rapidly formed, and, so far as we know at present, brought to a close that period of rest in the volcanic activity during which these sedimentary beds had been accumulating.

The following analyses of the more spheroidal portion of the Ballypalidy ore indicate a close affinity with the pisolitic iron-ore of Tully, near Glenarm (see p. 159), and confirm our observations as to the source whence the ferruginous materials of the irregularly stratified beds at Ballypalidy have been derived.

*Analyses of Brown Aluminous Hœmatite **.

Sesquioxide of iron	35·91	27·93
Protoxide of iron	6·57	5·08
,, of manganese	0·05	tr.
Alumina	27·95	34·57
Lime	0·60	0·91
Magnesia	0·20	0·62
Potash	0·49	—
Silica	9·75	9·87
Phosphoric acid	—	tr.
Water	18·60	19·36
Titanic acid	—	3·51
	100·12	101·85

4. *Plant-remains of the Series.*—Though Mr. Baily's account of the plants found at Ballapalidy is the first published record of the occurrence of vegetable remains associated with the basalts of Antrim, yet their presence in these same beds was known as early as 1862, soon after the commencement of mining operations at that locality. The discovery we owe to Mr. Rowland Smeeth, a pupil of one of us; and it was made public in a course of geological lectures delivered at Belfast. The plants then obtained were few in number, *Pinus* and *Cupressites* being the only forms identified. But the priority of discovery of plants in the Antrim basalt we accord to Dr. J. Bryce, F.G.S., who, with an unaccountable diffidence, hesitated to make known his researches, though a favourable opportunity offered on the

* Percy, Metallurgy of Iron, p. 207.

occasion of the reading of the Duke of Argyll's paper on the "Leaf-beds of the Isle of Mull." The plant-remains were obtained on the shores of Lough Neagh, near Shane's Castle, and opposite Ram's Island, on the east shore of the Lough. These and other species additional to those enumerated by Mr. Baily from the Antrim basalt concur to fix the period of their growth on the horizon of the Upper Miocene, and to establish a contemporaneity with the florula of the Basalts of Mull.

Amongst the plant-remains from the ash-beds on the shore of Lough Neagh, collected by Dr. Bryce, we recognize *Platanus aceroides*, *Sequoia Langsdorfi*, species of *Juglans*, *Fagus*, *Laurus*, &c. And from the sedimentary ochreous beds at Ballypalidy we have collected the following unrecorded forms:—*Eucalyptus oceanica*, Ung., *Hakea*, sp., *Celastrus*, sp., *Daphnogene Kanii*, Heer ?, *Graminites*, sp., &c.

V. Economics and mineral Statistics.

The Antrim iron-ore, though of but recent introduction, has already attracted some attention among the iron-masters in England. Its freedom from deleterious substances, such as phosphorus and sulphur, and from any qualities injurious to the production of superior iron, commends it highly, while the presence of titanic acid in the pisolite-bed adds much to its value for the production of steel. But it is the high percentage of alumina that claims for this ore peculiar importance.

Mr. S. Evans, who has introduced much of this ore into England, informs us that its value as a flux is becoming more and more appreciated, and that the furnaces of Cumberland and Lancashire are now supplied with large quantities for mixing with the siliceous hæmatites of that district. The effect of combining these two ores in the furnace is to soften the slag and to produce what is called a "loose load," which allows the metal to pass through with facility, and at the same time acts as a protection to the inner casing of the furnace. But, in addition to these valuable properties, the alumina determines the separation of the silica from the hæmatite-ores, thereby producing from a given quantity a larger percentage of metallic iron than could otherwise be obtained.

The great difficulty hitherto has been to produce an iron free from silica for the Bessemer process of steel-iron making. The Cumberland ore has been found well adapted for producing this steel; but the contained silica has always been a drawback, injurious and difficult to remove. The great demand is for an iron free from silica; and since the Antrim ore has entered the market this desideratum has been accomplished: it contains little or nothing deleterious, and yet has within itself the essential properties for making a superior steel-iron, while the large excess of alumina acts as a purifier to the richer ferruginous ores, and has thus enabled the Cumberland and Lancashire furnaces to stand first in producing the most suitable iron for Bessemer's process.

It is not difficult to discern that other districts will soon learn the

value of this ore. The poorer kind, as lithomarge, may be used as a flux, while the richer bole and pisolite are made to yield a superior iron, suitable alike for steel- or machinery-purposes*.

The growing demand for this Antrim ore proves its utility; during the past year upwards of 50,000 tons were shipped to England from several ports along the Antrim coast. The mining has become a steady and increasing industry in the county.

VI. General Conclusions.

1. That during the period of volcanic activity in the N.E. of Ireland, there was a cessation of igneous eruption over certain areas, during which lacustrine deposits were formed, and a growth of terrestrial plants took place.

As to the extent of the lake, or of the land-surface, the data are incomplete to form any conclusions. The lignite in the Giant's-Causeway basalt, the leaf-beds of the Isle of Mull, and the bituminous deposits in other localities may be on the same horizon. However, it is perhaps more probable that these several land-accumulations may have been formed in isolated areas, though during the one period of rest in the volcanic forces.

2. The preceding remarks imply that there were at least two periods of volcanic activity, the plant-beds or lignite marking an unconformability of an upper basaltic series to a lower. The plants being of Upper-Miocene age enables us to assign a position in the scale of geological time to the superior basalts. What may be the age of the inferior series, is a question that can only be approximately answered. That it is newer than the White Limestone (Upper Chalk) and older than the upper Miocene, is apparent.

3. The older basaltic series has undergone metamorphic changes in the composition of some of its interstratified lavas. The boles and ochres, which are decomposed basalts, are probably connected with subaqueous igneous flows, whilst the pisolitic iron-ore band, which is a metamorphosed *bole*, indicates subaerial action, and that during the period of emergence the bole was subjected to further metamorphism by heated superimposed basalt.

Discussion.

Mr. D. Forbes was not prepared to admit some of the theoretical conclusions of the authors, and objected to calling in metamorphism to account for all that was hard to be understood. He could not recognize the division of beds so similar in character into two classes. He wished to know, assuming that the iron-ore merely resulted from the decomposition of the basalt, what became of all the silica and alumina which constituted three-fourths of the mass. The origin of the pisolitic ores was in fact organic. In Sweden certain lakes were regularly dredged each year for the pisolitic ore still in

* It would be of great importance to the prosperity of the north of Ireland if the ore could be smelted at home. Furnaces might easily be erected near the mines for the reduction of the richer pisolite; limestone is abundant; and coal can be procured easily and cheaply from Scotland.

course of formation by means of confervoid algæ. He therefore regarded the whole of these beds as in a certain sense sedimentary, and though due to organic agency, yet still deriving their original mineral matter indirectly from the basalt. The basalt contained a considerable amount both of phosphorus and sulphur; and if the ores had been derived directly from the basalt, both these substances would have been present in them. This was an argument against any direct metamorphism. The presence of vanadium afforded additional reason for regarding these ores as formed in the same manner as bog-iron and similar ores.

Sir Charles Lyell had observed in the basalts of Madeira red ochreous bands which represented old land-surfaces, in one of which Mr. Hartung and he had discovered a leaf-bed containing vegetation of much the same character as that of the island at the present day. Near Catania, in a recent lava-stream, he had seen the junction of the lava with the soil of the ancient gardens; and in character the soil now under the lava resembled the red beds of Madeira.

Mr. W. W. Smyth was on the whole inclined to admit the power of metamorphism to produce such changes as had been here effected. He commented on the advantages of employing this Irish ore for admixture with hæmatitic ore, on account of the abundance of alumina present. Possibly there had been some difference in the chemical character of the different flows of basalt.

Mr. Evans suggested that the Ballypalidy beds might be the littoral deposits of a lake in which the pisolitic ores of the other parts of Antrim were deposited further from the shore, and subsequently buried under a basaltic flow.

Mr. Etheridge inquired whether the pisolitic ore had been subjected to microscopic examination, with a view of finding traces of organic forms, such as *Gaillonella*.

Mr. Tate, in reply, defended his views as to metamorphic action. He thought the uniformity in thickness and character of the pisolitic ore band over so large an area showed that it could not be a lacustrine deposit. He had not as yet discovered any diatoms in the spheroids.

---

2. *Notes on the* Structure *of* Sigillaria.

By Principal Dawson, F.R.S., F.G.S., Montreal.

[The publication of this paper is deferred.]

(Abstract.)

In this paper the author criticised the statements of Mr. Carruthers on the structure of *Sigillaria* (see Q. J. G. S. xxv. p. 248). He remarked that *Sigillaria*, as evidenced by his specimens, is not coniferous, that the coniferous trunks found in the coal-formation of Nova Scotia do not present discigerous tissue of the same type as that of *Sigillaria*, that no conifer has a slender woody axis surrounded by an enormously thick bark, that *Calamodendron* was probably a Gymnosperm and allied to *Sigillaria*, that, although *Stigmaria* may not always show medullary rays, the distinct sepa-

ration of the wood into wedges is an evidence of their having existed, that the difference in minute structure between *Sigillaria* and *Stigmaria* involves no serious difficulty if the former be regarded as allied to Cycadeaceæ, and, further, that we do not know how many of the *Stigmariæ* belong to *Sigillaria* proper, or to *Favularia,* or to such forms as *Clathraria* and *Leioderma,* which may have been more nearly allied to *Lepidophloios,* that the fruit figured by Goldenberg as that of *Sigillaria* is more probably that of *Lepidophloios,* or may be a male catkin with pollen, and that he has found *Trigonocarpa* scattered around the trunks of *Sigillariæ* and on the surface of the soil in which they grew. He agreed with Mr. Carruthers in regarding Mr. Binney's *Sigillaria vascularis* as allied to *Lepidodendron.*

Discussion.

Prof. Morris thought that *Clathraria* and *Lepidophloios* ought to be discriminated from the *Sigillariæ,* as being rather more nearly allied to cycadeaceous plants, especially the former. He pointed out the manner in which certain vascular bundles communicating between the centre of the stem and the bark in *Sigillaria* and allied genera might be mistaken for medullary rays.

---

3. *Note on some new* Animal Remains *from the* Carboniferous *and* Devonian *of* Canada. By Principal Dawson, F.R.S., F.G.S., Montreal.

(The publication of this paper is deferred.)

[Abstract.]

The author described the characters presented by the lower jaw of an Amphibian, of which a cast had occurred in the coarse sandstone of the Coal-formation between Ragged Reef and the Joggins Coal-mine. It measured 6 inches in length; its surface was marked on the lower and posterior part with a network of ridges enclosing rounded depressions. The anterior part of the jaw had contained about 16 teeth, some of which remained in the matrix. These were stout, conical, and blunt, with large pulp-cavities, and about 32 longitudinal striæ corresponding to the same number of folds of dentine. The author stated that this jaw resembled most closely those of *Baphetes* and *Dendrerpeton,* but more especially the former. He regarded it as distinct from *Baphetes planiceps,* and proposed for it the name of *B. minor.* If distinct, this raises the number of species of Amphibia from the Coal-measures of Nova Scotia to nine.

The author also noticed some insect-remains found by him in slabs containing *Sphenophyllum.* They were referred by Mr. Scudder to the Blattariæ.

From the Devonian beds of Gaspé the author stated that he had obtained a small species of *Cephalaspis,* the first yet detected in America. With it were spines of *Machairacanthus* and remains of some other fishes. At Gaspé he had also obtained a new species of *Psilophyton,* several trunks of *Prototaxites,* and a species of *Cyclostigma.*

Discussion.

The President objected to the term Reptiles being applied to Amphibia, from which they were totally distinct. He questioned the safety of attributing the jaw to *Baphetes*, of which no lower jaw had been previously found.

Mr. Etheridge remarked that the *Cephalaspis* differed materially in its proportions from any in either the Russian or the British rocks.

4. Note *on a* Crocodilian Skull *from* Kimmeridge Bay, Dorset. By J. W. Hulke, Esq., F.R.S., F.G.S.

[Plate IX.]

A closer examination lately made by Mr. Davies, Sen., of the fossils presented to the British Museum last year by J. C. Mansel, Esq., has led to the identification of a large crocodilian head with the Saurian the lower jaw of which I described last session, and identified with *Dakosaurus maximus* of Quenstedt. Covered with matrix, this head had been previously put aside as Pliosaurian, other Pliosaurian remains having been presented to the Museum by the same munificent donor; but now that its identity has been correctly established, a short account of it seems to be a fit sequel to my last paper.

The general agreement of their dimensions, and their discovery near together (in a reef exposed at low water in Kimmeridge Bay), make it highly probable that this head and the lower jaw both belonged to one individual.

The considerable part of the head discovered by Mr. Mansel includes the back of the skull, the left upper temporal arcade, and the entire snout. The extremity of this latter is completed by the præmaxillæ figured in the last number of our Journal, the sutures in which so exactly coincide with those in the broken end of the snout that there cannot be any doubt of the correctness of this restoration.

The shape of the head is a long triangle; its sides converge from the occiput to the end of the snout, with a slight outcurve of the temporal arcade, a moderate incurve in front of the orbits, and a very slight inbend behind the nostril. Its base, a narrow occipital crest, slopes downwards and outwards from a lofty sagittal crest to the truncated mastoid angles.

The skull has the characteristic narrowness of the temporal region, the extremely large crotaphite foramina, the lofty sagittal crest, and the lateral orbit which mark Geoffroy Saint-Hilaire's subgenus *Steneosaurus* *.

The sagittal crest, in its present mutilated state, rises two inches above the brain-cavity; a coarse diploë fills the interspace. The crota-

* Geoffroy Saint-Hilaire, "Recherches sur l'organisation des Gavials," &c. Mémoires du Muséum d'Histoire Naturelle, t. xii. pp. 148, 149 (Paris, 1825).

phite foramina have a squarish outline, and from back to front they measure nearly six inches. The temporal arch is proportionately long and strong; the occiput is broad and low; the angular crest already noticed forms its upper limit; its lower border is thin and nearly straight. This and the greater part of the posterior surface appear to be formed by an outward extension of the exoccipital to the mastoid and quadrate bones. The surface, generally flat, is crossed on the level of the foramen magnum by a horizontal ridge, which makes an acute angle with the outer end of the occipital crest. Between this ridge and the crest the surface is depressed and slightly overhung by the latter. Beneath the outer end of the ridge is a deep hollow. The foramen magnum is an ellipse; its horizontal axis measures 1·1 inch, and its vertical axis ·8.

The occipital condyle is broken off, as is also the articular end of the quadrate bone. Of the orbits, only the front and upper part of the left one remains; its lateral position gives its opening an outward direction; its anterior border seems to have scarcely risen above the level of the surrounding parts. A furrow probably marks off the lachrymal from the præfrontal bone. Between the orbits, the broad forehead, now very mutilated by fractures, appears to have been gently convex. The sutures are here too indistinct to allow me to speak with certainty of the forms and limits of the bones composing this region.

The snout is shorter than that of the Honfleur Gavial "tête à museau plus court." A pair of large triangular bones united by a mesial suture 9 inches long, descend from the forehead to the middle of the snout, forming a great part of the upper surface in this situation. Their posterior limit is not accurately determinable. It appears to be invaded by a descending process of the præfrontal. Their outer border is conterminous behind with the maxillary bone. In front they form conjointly a broad wedge. These bones evidently correspond in their position and in their relations to the pair of bones lettered *a a* in the illustrations of the Honfleur Gavials in the 'Ossemens Fossiles,'* which Cuvier called nasals. He refers to them in these words:—"On y voit, en *a*, les extrémités antérieures des os du nez, formant comme dans le Gavial, une pointe précédée par la réunion des maxillaires, *b b*, qui continuent le tube des narines en avant jusqu'aux intermaxillaires."

The same bones are plainly indicated in a cast of a crocodilian snout in the Museum of the Royal College of Surgeons, described in the catalogue as a cast of the snout of *Steneosaurus robustus*, presented by Dr. Buckland. Dr. Rolleston, in reply to my inquiry, informs me that these bones are also shown in a cast of the Honfleur (Geneva) Steneosaur in the Oxford Museum †, and that the relations of the bones in the upper surface of a Steneosaurian skull from

* Cuvier, 'Ossemens Foss.' tome 5, 2e partie, pl. x. figs. 1 & 5, *a a*.

† I suspect that the figure in the Bridgewater Treatise was taken from one of these casts; for the drawing contains a long, hard, straight line, which corresponds to a ridge in the cast in the Royal-College-of-Surgeons Museum, formed by the plaster getting into a joint of the mould.

Shotover exactly correspond with those figured in the 'Ossemens Fossiles.'

So far, then, as regards the proximal half of its snout, this Kimmeridge Steneosaur apparently agrees with the Honfleur Gavials, and with the Oxford (Shotover) Steneosaurian skull, in the presence and in the relations of this pair of large triangular bones. The distal half, however, is differently constructed; for in the Kimmeridge Steneosaur Cuvier's large triangular nasals are preceded by a pair of distinct slips, which are intercalated first between the maxillaries, afterwards between the intermaxillaries, and which finally enter the posterior border of the external nostril, where they form a low mesial projection, on each side of which is a vertical groove. The posterior ends of this mesial pair of slips taper acutely; and, diverging widely, they embrace for 3·5 inches Cuvier's large nasals, having these on their inner edge and the maxillaries on their outer border. Between the point where they diverge and the external nostril, a distance of nearly six inches, their inner borders meet in the middle line; and their width averages ·9 inch, decreasing slightly towards the nostril.

This is an important difference: the external nostril of our Kimmeridge Steneosaur is not completely enclosed in the præmaxilla as in the Teleosaurs and recent Gavials, and as it is described in the Honfleur Gavials and the Oxford (Shotover) Steneosaurian skull, but its posterior border contains another element, the anterior ends of a mesial pair of bones, the distal six inches of which have the same relations to the maxillaries and intermaxillaries and to the nostril as the nasals in the crocodiles and in the alligators.

The nostril is subterminal, oval, the larger end behind. Its opening, directed upwards, is indented in the middle line, in front by the præmaxillary symphysis, and behind by the ends of the slender *nasals* (?), as just described.

The præmaxillæ ascend 2·2 inches behind the nostril, wedged in between the maxillaries and slender *nasals*. Their inner border, touching the latter, is straight. The suture which joins their outer border to the maxillary is oblique; it crosses the dentary margin of the snout just in front of the fourth alveolus.

There are seventeen alveoli on each side; the hindmost one visible, in the left side, is so small that it is almost certainly the last; but since the edge of the jaw is deficient behind it, I cannot be absolutely sure of this. The first three teeth are contained in the præmaxilla; and the interval between the third and the fourth tooth is rather wider than those between the rest.

The teeth, some of which are still in the sockets, while others are scattered loose over the palate, correspond with those of the lower jaw, and therefore do not require description. Their size and figure vary within rather wide limits, as they do in many living crocodiles; but the essential features are constant.

The palatine plates of the præmaxillaries and of the maxillaries, and the inner edges of the palatine bones (so far as these latter are preserved), join in the middle line, and make the bony palate very

complete. In front it is flat; but from the middle of the snout backwards the inner border of the maxillaries and of the palatine bones form a low median ridge, which makes the palate in this part convex transversely.

The præmaxillary sutures form an acute angle open behind, as they do in *Steneosaurus rostro-minor*. I cannot speak with certainty of the suture between the maxillary palatine plates and the palatine bones; it seems to be a straight transverse line.

The anterior palatine foramen is small; it is situated opposite to the interspace between the second and third teeth. The front end of the posterior palatine foramen, angular and narrow, is seen opposite to the penultimate tooth.

It will be recollected that in my last paper I showed that the lower jaw and præmaxilla of this Kimmeridge crocodilian so closely resembled those of Cuvier's second Honfleur Gavial "tête à museau plus court" (*Steneosaurus rostro-minor*, Geoffroy St.-Hilaire) as to afford a very strong presumption of their specific identity; and I identified it by means of its teeth with *Dakosaurus maximus*, Quenstedt. The more rigid comparison which the additional material since acquired has made possible, confirms the opinion thus expressed, that this Kimmeridge crocodilian is really a Steneosaur; but it also proves it to be a distinct species. Its snout is stouter than that of the two Honfleur Gavials; the structure of its distal half differs from that which obtains in these and in the Oxford (Shotover) Steneosaur. The number and distribution of the teeth differ also considerably from those in the "tête à museau plus court," which has 22 teeth in each half of the lower jaw, of which 7 are postsymphysial; while the lower jaw of the Kimmeridge Steneosaur has not more than 15 teeth on each side, and of these at most 4 are behind the symphysis.

For this new Steneosaur I propose the specific name *Manselii*, in honour of its discoverer:—*Steneosaurus Manselii*.

Dec. 1869.

Postscript.—I cannot quite shake off the suspicion that the slender nasals may be present in the Geneva snout, and perhaps also in the Oxford (Shotover) Steneosaur's skull.

Cuvier, in describing the nostril of the Honfleur gavial "tête à museau plus court," says, "Le bord postérieur et supérieur donne deux petites proéminences qui ne sont pas au Gavial. Les sutures ne sont pas assez marquées pour que je puisse déterminer si ces proéminences appartiennent aux maxillaires ou aux intermaxillaires" *.

Dr. Rolleston, also, writing to me about the Oxford (Shotover) skull, says, "Some restitutive plastering has taken place at the nasal opening; but into it there projects, from behind forwards, in the middle line, an azygos process. What this is the sutures are not, I think, present to show; but you will judge."

* Ossemens Fossiles, tome v. 2e partie, p. 153.

Now "ces deux petites proéminences" and the azygos process in the Oxford (Shotover) skull make it highly probable, I think, that the slender anterior nasals are really present in these Steneosaurs; but the indistinctness of the sutures prevented their recognition.

Not remembering one crocodilian skull, fossil or recent, in which the maxillaries entered into the construction of the external nostril, I examined, with special regard to this point, the large collection of recent skulls in the British Museum, comprising more than fifty skulls, including every known species of the gavial, crocodile, and alligator types, and also all the skulls in the Museum of the Royal College of Surgeons; and I did not find one where the maxillaries formed part of the opening of the anterior nostril. In every instance this was formed of the præmaxillaries alone, as in the Gavials, or by the præmaxillaries and the nasals. I could not find one example of a median process projecting forwards from the posterior border of the nostril formed of the præmaxillaries. Such a process always consisted of the anterior extremities of the nasal bones, which either entered the posterior border of the nostril in the plane of the external opening (in most alligators), or below this plane (in many crocodiles, where the junction of the præmaxillaries behind the nostril concealed and overlay the front ends of the nasals, which descended into the nostril beneath them). In some skulls the nasal process received a small accession from the præmaxillaries; but this was always subordinate to it, and never reached beyond its base. In Gavials also (where the intermaxillaries alone enclose the nostril) these minute projections of the intermaxillæ into the nostril were sometimes present, but they were dwarfed and insignificant.

Should my suspicions prove correct, and *Sten. rostro-minor* and the Oxford (Shotover) skull be found to have the slender nasals of *Sten. Manselii*, this last will still be distinguished from *Sten. rostro-minor* by the different proportions of its skull, and the number and the distribution of its teeth.

What are the two large triangular bones in *Sten. Manselii* which descend from the forehead to the middle of the snout? Evidently they correspond to the bones marked *a a*, fig. 5, pl. x., 'Ossemens Fossiles.' They are, I imagine, the principal frontal, retaining permanently in the adult Steneosaur the median suture which primitively divides it in the embryonic crocodile. Attaining in the Steneosaur a very large size, the divided frontal thrusts aside the posterior ends of the nasals, and, uncovered by these, forms so large a part of the surface of the snout. Its excessive descent, however, is less than at first sight appears; for it is well known that in existing crocodiles the frontal, which seems to end in front of the orbit, really only disappears from the surface here, and beyond this, hidden and overlain by the præfrontals and nasals, it stretches forwards a long distance—in *Croc. vulgaris* exceeding one-third of the distance between the orbit and nostril.

Dimensions.

	inches.
Length of skull from præmaxillary symphysis to occipital crest	33
From præmaxillary symphysis to (broken) articular end of tympanic bone	37
From præmaxillary symphysis to posterior limit of (anterior) nasal bones	14
From præmaxillary symphysis to point of Cuvier's large nasals	10
From præmaxillary symphysis to end of their median suture	19
Length of crotaphite foramen	6
Breadth of crotaphite foramen, about	6
Breadth of forehead between orbits	7
Breadth of snout at second tooth	3·1
Breadth at middle of dentary series	5·6
Breadth at hindmost tooth	10·2
Breadth of occiput 7·5×2	15
Height of occiput	7·3
Length of alveolar series (left side)	23·4
From præmaxillary symphysis to the anterior palatine foramen	1·9
From præmaxillary symphysis to palato-maxillary foramen	21

EXPLANATION OF PLATE IX.

Fig. 1. Under surface of skull of *Steneosaurus Manselii.*
- *a.* Anterior palatine foramen.
- *b.* Præmaxillary-maxillary suture.
- *c.* Anterior extremity of pterygo-maxillary foramen.
- *d.* Basisphenoid.

2. Upper surface of skull.
- *a.* The triangular bones corresponding to those lettered *a a* in Cuvier's figure of upper surface of snout of Gavial tête à museau plus court.
- *b.* The nasals.
- *c.* Their anterior termination in the nostril.
- *d.* The orbit.
- *e.* Parietal crest.

---

5. NOTE *on some* TEETH *associated with* TWO FRAGMENTS *of a* JAW *from* KIMMERIDGE BAY. By J. W. HULKE, Esq., F.R.S., F.G.S.

AMONGST many other Kimmeridge fossils which Mr. J. C. Mansel has intrusted to me for examination are two pieces of a long, slender snout, not unlike that of a long-beaked *Ichthyosaurus*, but too fragmentary and crushed to allow of their certain identification.

The teeth differ from those of all the fossil fish and reptiles in the British Museum with which I have been able to compare them. They are peculiar in the great development of the cementum, which gives the fang the appearance of being inserted in a bulbous sheath. The base of the tooth resembles a little bulb, from the top of which a slightly curved, cylindrical, conical, and polished crown protrudes. The average length of the teeth is nearly $5\frac{1}{2}$ lines (English), of which about $3'''$ belong to the neck and crown. The diameter of the neck and of the neighbouring part of the crown is about $1\frac{1}{6}'''$, while that of the bulbous fang reaches $2\frac{1}{6}'''$. The crowns are dark brown, polished, and smooth, and their transverse section is circular. They are composed of a simple tubular

Fig. 1.

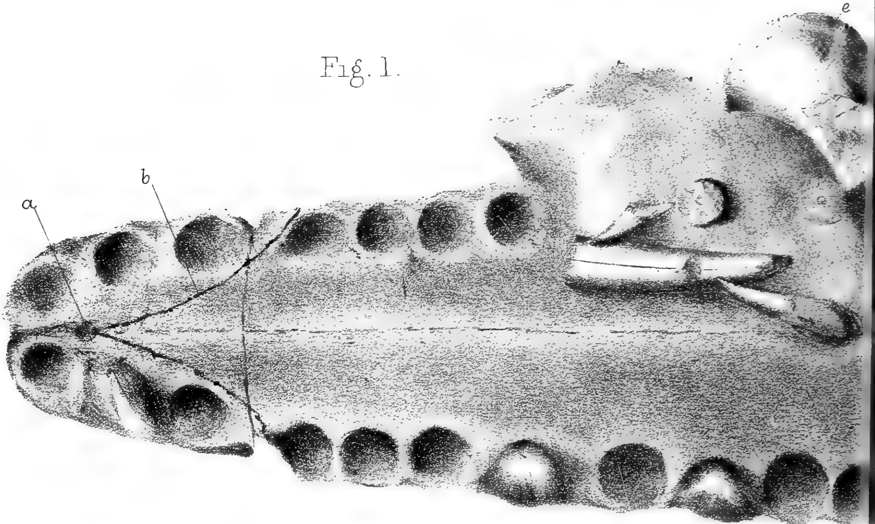
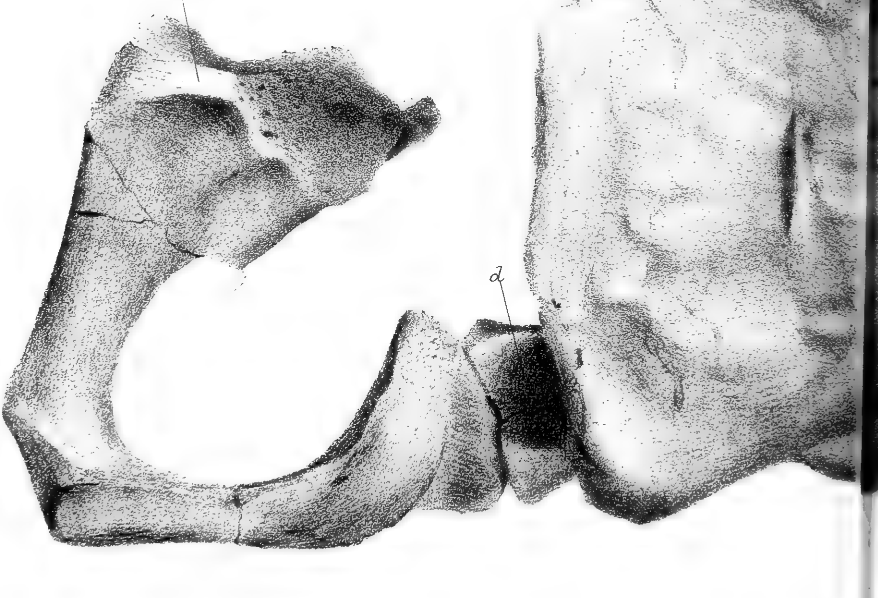
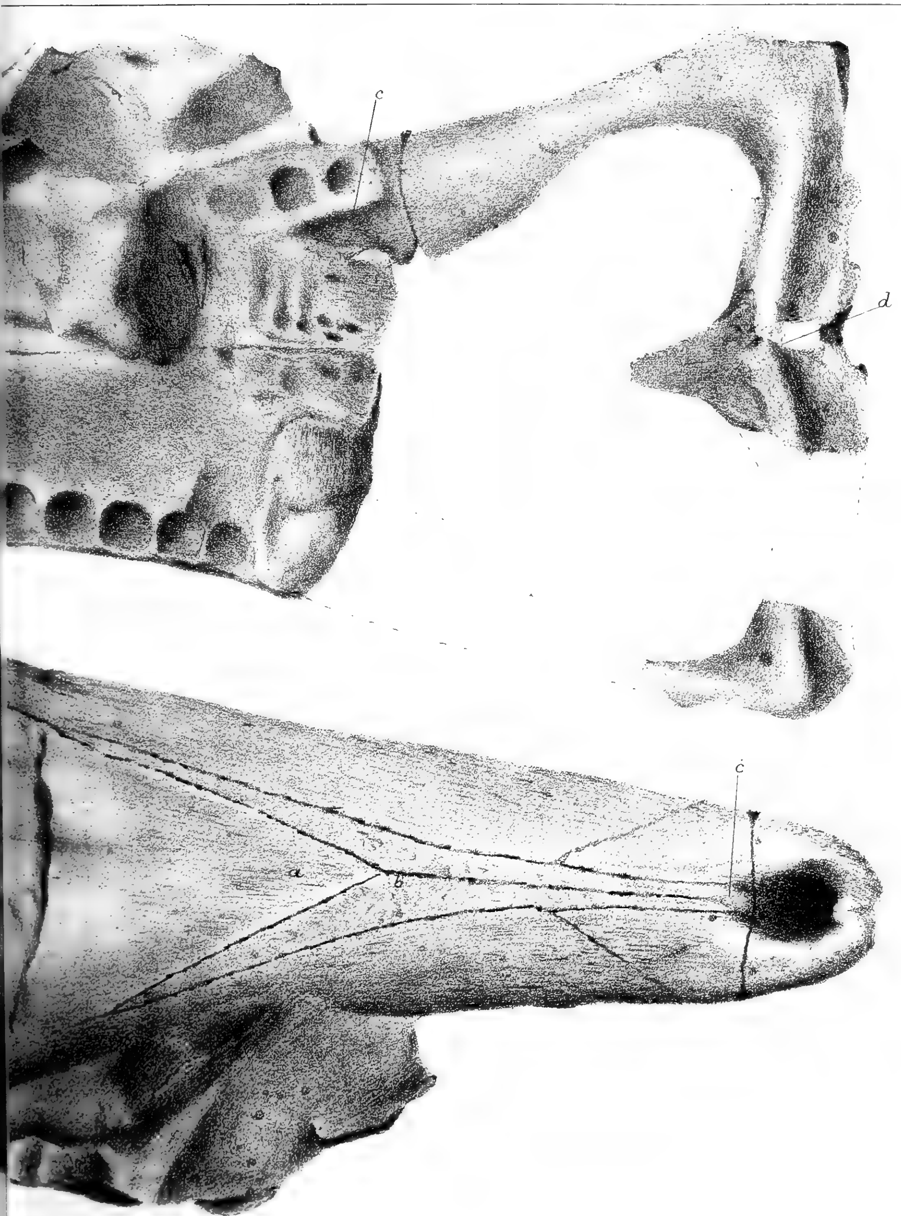


Fig. 2.



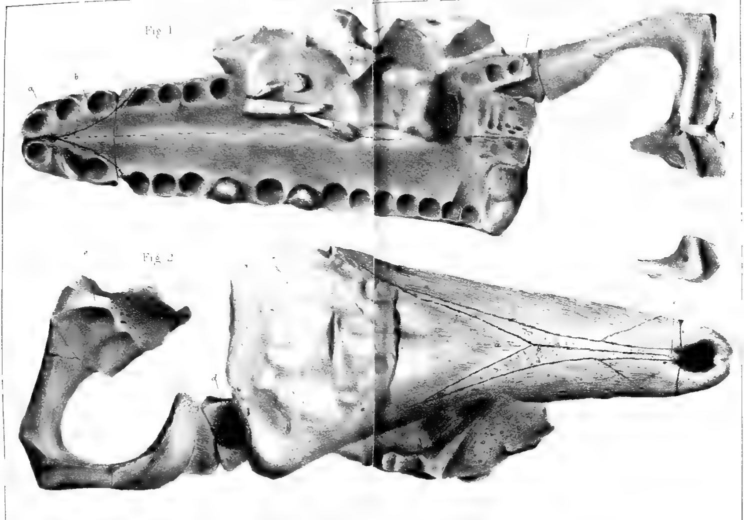
Murdoch S Morison del. et lith.

SKULL OF STE



W West imp.

[…]SAURUS MANSELII.



Murdoch S Morison del et lith. W West imp

SKULL OF STENEOSAURUS MANSELII

dentine, coated with a thin layer of enamel. The dentinal tubules pass straight from the pulp-cavity towards the enamel without waving, in which respect, and in the almost complete absence of the concentric granular rings, which are so conspicuous a feature in the dentine of many crocodilian teeth, the dentine of these teeth resembles that of the unfluted apex of an Ichthyosaurian tooth-crown. The enamel, however, is thinner than that of several sections of Liassic Ichthyosaurian teeth of about the same diameter. At the base of the fang the dentine, owing to the presence of a large pulp-cavity, becomes thin; and its contour is here slightly and irregularly indented, but the indentations are quite insignificant in comparison with the deep inflexions which distinguish the tooth-fang in *Ichthyosaurus*. The pulp-cavity extends into the base of the crown. Its apex is filled with spar; and its lower end contains a plug of ossified tooth-pulp, continuous through the open end of the cavity with the external cementum, its vascular canals freely inosculating with those of the cementum in this situation. The vascular canals of the cementum are large and numerous. Their principal branches take the direction of the long axis of the fang, running from the base towards the neck. The bony tissue channelled by them abounds in lacunæ, which do not differ in any essential particular from those of the bones which bear the teeth.

The connexion of the teeth with the jaw appears to resemble that which obtains in *Ichthyosaurus*: they are neither soldered to a flange nor implanted in sockets, but they are arranged in a line in an open groove in the upper surface of the jaw. Several of them are displaced out of the groove, which shows the absence of anchylosis to the dentary bone, and that they were attached to it only through the medium of the soft tissues. Of the teeth remaining *in situ*, six occupy 1·5 inch.

The swelling caused by the great development of the cementum gives these teeth some resemblance, but only of a superficial kind, to those of the Chalk "Fossil Fish or Reptile" lately purchased by the British Museum, formerly in the collection of Mr. Toulmin Smith, who described it in Charlesworth's 'London Geological Journal,' No. 1. Sept. 1846. Mr. Bowerbank afterwards referred to it in a paper on bone corpuscles. The teeth are here inserted in bony cups; and Mr. Smith expressed the opinion that these were shed together with the teeth. The occurrence of gaps in the dentary series from which both cup and tooth are absent probably led to this view; but there are also several full-sized empty cups without teeth in them, which demonstrates that the cup and tooth do not in every instance simultaneously disappear, and renders it very unlikely that any hard structural connexion existed between them. I think it more probable that the tooth was generally first shed, or detached by violence, and that after this the cup was removed by the abrasion of its thin unprotected edge, and by absorption.

As well as I can judge, in the absence of sections through the tooth-cup and bone which bears it, the cups are upgrowths from the

surface of the bone, which envelope the base of the tooth, but do not form an integral part of it. The attachment of the teeth in *Acrodontosaurus Gardneri* is, I suspect, of this kind. The microscopic preparations which the British Museum has of Mr. Toulmin Smith's fossils are too few and too imperfect to completely illustrate its histology, but what they do show is piscine rather than reptilian.

The minute structure of these Kimmeridge teeth is, I think, reptilian rather than piscine. In the characters of their dentine, in the persistence of the upper end of the pulp-cavity and the ossification of the base of the pulp, and in the mode of their attachment these teeth show an approach towards *Ichthyosaurus*; but there are also differences, which may not safely be overlooked; and until new material puts its true nature beyond doubt, I propose to place this fossil by itself, and to call it provisionally *Enthekiodon*.

January 12, 1870.

John Aitken, Esq., J. P., of Bacup, President of the Manchester Geological Society; Edward Allen, Esq., 19 St. Saviourgate, York; Clement Cadle, Esq., Gloucester; Arthur Wyatt Edgell, Esq., of Lympstone, Exeter; Charles F. Leaf, Esq., F.L.S., Old Change, and Harrow; and Samuel Joseph Smith, Esq., 29 Park Road, New Wandsworth, were elected Fellows of the Society. Professor Otto Torell, of Lund, was also elected a Foreign Correspondent of the Society.

The following communications were read:—

1. *On the* Geological Position *and* Geographical Distribution *of the* Reptilian *or* Dolomitic Conglomerate *of the* Bristol Area. By Robert Etheridge, Esq., F.R.S.E., F.G.S., Palæontologist to the Geological Survey of Great Britain.

1. Introduction.
2. History.
3. Mode of occurrence.
4. Geographical Distribution of, or Area occupied by the Dolomitic Conglomerate.
5. Influence of the Conglomerate upon the production of Minerals.
6. Position in time of the Reptilian remains with relation to the Conglomerate.
7. Zoological Contents or Fauna of the Dolomitic Conglomerate.
8. Stratigraphical relation of the Reptilian Conglomerate to Continental Deposits.
9. Table of Equivalents.

1. Introduction.

It is so long since any communication has been made to the Society upon the Dolomitic Conglomerate in a physical sense, that it appeared to me the time had arrived when a paper in our Journal embodying some general notice or history of the conglomerate might not be unacceptable, especially as the Dinosauria of the Trias have

lately been so ably treated by Prof. Huxley. This paper is therefore devoted to a consideration of the geological position and geographical distribution of the conglomerate so widely spread over the Bristol area, and containing the remains of the Dinosaurian reptiles *Thecodontosaurus* and *Palæosaurus*.

I have little to communicate that has not been noticed by the older writers; and the mention of the names of Bright, Gilby, Buckland, Conybeare, De la Beche, and Murchison, will show how little is left for me to do; but uninviting as this nearly unfossiliferous rock may appear at first sight, it nevertheless possesses a history even yet not written, and its origin, date, and fauna are still matter for investigation and research.

This old breccia is a grand and striking feature over many parts of the area where it is well exposed, and is a marked condition in the geological history and physical structure of Britain, to be studied and understood only over the limited and complicated area occupied by the palæozoic rocks of the Bristol coal-basin.

2. History.

So long ago as the days of Richard Bright and Dr. Gilby, in 1811–16, the age and position of the dolomitic conglomerate of the Bristol area perplexed geologists.

The late able papers by Prof. Huxley, communicated to this Society *, have again opened up the question in connexion with the position in time and space to be assigned to two genera of Dinosauria, a question of much interest, as tending to clear up the age, position, and distribution of certain Reptilia occurring in many parts of Europe, Asia, Africa, and America. Again, the relation of the conglomerate in question to the older rocks on which it rests, as well as to the sandstones and marls associated with it, is a matter of much local interest.

I propose discussing this question on physical grounds only, and as an accompanying paper to that of Prof. Huxley upon the palæontological contents of certain rocks in the Bristol area called dolomitic conglomerate.

The only remains ever found belonging to the dolomitic conglomerate were described by Messrs. Riley and Stuchbury in their able paper in the 'Transactions of the Geological Society,' vol. v. 2nd ser. p. 349, read in 1836 (published 1840); and lately much additional matter has been added by Prof. Huxley in his paper upon the classification and affinities of the Dinosauria †.

This singular deposit is locally called the Magnesian or Dolomitic Conglomerate ‡, so termed from the presence of dolomite, or carbo-

* Quart. Journ. Geol. Soc. vol. xxvi. p. 12: "On the affinity between the Dinosaurian Reptiles and Birds." "On the classification of the Dinosauria, with observations on the Dinosauria of the Trias," *ibid.* p. 32.

† Quart. Journ. Geol. Soc. vol. xxvi. pp. 32–50.

‡ The Yorkshire and Nottinghamshire dolomite or magnesian Limestone is an independent member of the Permian, and must not be confounded either

nate of lime associated with carbonate of magnesia, forming a pasty cement by which the rounded boulders and pebbles constituting the deposit are firmly held together; it is not to be confounded with the Permian magnesian limestones of the N.E. of England. The proportion of lime and magnesia appears to be indefinite in the uncrystallized dolomite, which is a mere mixture of true dolomite and carbonate of lime.

Messrs. Buckland and Conybeare were the first to apply the term "dolomite" both to this formation and to the carboniferous limestone when *dolomitized in situ*, or so-called dolomitized limestone.

In 1817 Mr. Warburton * had previously stated with reference to the conglomerate and associated New Red Sandstone in the neighbourhood of Bristol and the Mendip Hills, that "if denudatory or other disturbing causes were in action previously to the deposition of the red marl, we might expect to find the red marl immediately incumbent upon any rock from the coal-measures to the granite inclusive."

Buckland and Conybeare in 1822 † showed that the older and disturbed rocks of the Bristol district were not only covered unconformably by various beds of the New Red Sandstone series, but also that higher formations, such as the Lias and Oolite, were brought into contact with them in the same relative position.

Messrs. Riley and Stuchbury subsequently had occasion to notice these beds under peculiar and interesting circumstances, announcing at the same time the discovery of two genera of reptilia in this conglomerate on Durdham Down, near Bristol; these they respectively named *Thecodontosaurus* and *Palæosaurus*. From that time to the present no occasion has arisen to call attention to these apparently uninteresting rock-masses, which, however, locally are of much importance.

I should, however, here mention that my valued friend, W. Sanders, Esq., F.R.S., of Clifton, during the construction of his large geological map ‡ of the Bristol coal-field was so impressed with the belief that the Dolomitic Conglomerate occupied in some places the lowest part, and in others the middle (in time) of the Keuper series, that he purposely omitted inserting the conglomerate as a separate formation upon his map, but incorporated or massed it with the New Red Sandstones and marls, calling the whole the Keuper marls and sandstones. His map therefore fails to show the geographical position of the conglomerate on the higher or more elevated tracts of land surrounding the Bristol coal-field. That he was right in associating it with and placing it at the base of the New Red Sandstones and marls cannot be doubted; and the numerous sections and conditions under which I have examined it, both in the

with the so-called magnesian limestone of Gloucestershire and Somersetshire (*which forms part of the dolomitic conglomerate*), or with the conglomerate itself.

* Trans. Geol. Soc. vol. iv. p. 209: 1817.

† Trans. Geol. Soc. 2nd ser. vol. i. p. 217, &c.

‡ Constructed upon the scale of 4 inches to the mile.

immediate Bristol area, and in the West-Somerset and South-Wales districts, convince me that the age of this conglomerate was the coming in or commencement of the Keuper in the area under consideration.

I must not omit also to state that Sir H. De la Beche in 1846 *, and subsequently in his 'Geological Observer' †, discussed this question and clearly defined the geological position and conditions of the dolomitic conglomerate. He has successfully shown that it was intercalated with the associated and succeeding sandstones and marls at many places, and during different periods, in and through the Keuper series, and even "continued up to and may have included the base of the Lias;" but we must guard against misunderstanding the two conglomerates, their palæontological contents being totally different.

There are many localities along the north side of the Mendip Hills, on steep or rising ground, where the intermingling of beach-like wedge-shaped masses with finer surrounding and associated sandstones constantly occurs, these finer accumulations not having been (in some places) removed by denudation. Again, we cannot doubt that the superincumbent marls and sandstones cover up or conceal enormous masses of widely spread conglomerate. This is especially the case over the upper coal-shales in the centre of the southern coal-field. The surrounding zone of Pennant and Lower Coal-shales, Millstone Grit, and Carboniferous Limestone also successively have their upturned edges more or less covered by the conglomerate, the so-called "*millstone*" or "overlie" of the coal-miners, as is proved by almost every coal-pit sunk in the southern basin; and the contents of the breccia or conglomerate at once determine the source of the pebbles.

The Geological Survey of Great Britain, in their published horizontal sections, have also distinctly shown, over the Mendip area, the recurrence of masses of conglomerate during the deposition of the whole Keuper series, and how not *one* only, but *many* beds of breccia, &c., with similar phenomena and under given conditions, occur along the strike of the palæozoic land, having been deposited throughout the whole time that the Keuper sandstone and marls were accumulating in a deeper or more open sea.

3. Mode of Occurrence.

To appreciate this fringe or existing remnant of a once widely spread mass of conglomerate nearly surrounding the Gloucestershire and Somersetshire coal-basin, it should be seen and examined *in situ*.

It has now the appearance of a line of consolidated shingle beaches remaining at their old levels with relation to the palæozoic rocks on which they rest and from which they were originally constructed. They represent an amount of time so vast, and a mass of old and lost land so great, that the mind almost re-

* Mem. Geol. Surv. vol. i. 1846.

† Geological Observer, 1853, pp. 476–496.

fuses to accept the fact that scarcely one-fourth of the older rock-masses of Somersetshire, Gloucestershire, and Glamorganshire now exist in their original conditions; and a careful study of the phenomena connected with the deposition and accumulation of the Dolomitic Conglomerate carries with it the conviction that this area, in the West of England, at the close of the coal-measures, on its elevation from profound depths, was subjected to great and long-continued denudation; and as the old land slowly rose, its original mass was greatly reduced by the action of the Keuper sea.

Prof. Ramsay, in 1846, in his elaborate memoir upon the "Denudation of South Wales and the adjacent English Counties"*, in discussing the probable presence of the lower members of the New Red Sandstone, suggests that these strata were either "destroyed after deposition or were concealed by overlapping upper beds of New Red, which, still resting in a comparatively undisturbed basin, may conceal the missing members in hidden hollows." This hypothesis is highly probable; but, up to the present time, it has not received confirmation.

We cannot, however, doubt that this conglomerate with its associated sandstone and marls† is part measure of the waste, and the result of marine and subsequent subaërial denudation under the agency of time; for whatever inequalities of coast-line or exposed masses existed at the close of the palæozoic period, it was during the formation of the conglomerates and breccias that they were removed, and the newer masses relatively arranged nearly as we now find them, thus furnishing us with data to calculate approximately the several levels or heights of the older continent above the level of the New Red sea (assuming the latter to have been constant), and thus enable us to find the age of the Dinosaurian conglomerate on Durdham Down near Bristol.

The average thickness of the New Red series over the Bristol area is about 250 feet, less by one-third than the same series in the northern and central part of England.

The lowest member recognized in the Bristol and South-Wales coal-field is the Dolomitic Conglomerate. I may, however, mention that in some localities there are no pebbles; for at Sully, on the Glamorganshire coast, the rock is perfectly homogeneous, and has the appearance of a dolomitized carboniferous limestone, and in many places the different conditions of these rocks pass so imperceptibly into each other that it is convenient to consider them all under the common appellation of conglomerates.

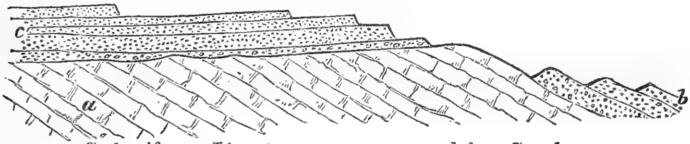
The average thickness of this conglomerate is about 20 feet, although many sections exhibit mural faces and slopes 40 or 50 feet in height or thickness. Occasionally it becomes so fine-grained and highly charged with the cementing matter, that it assumes the character of a compact dolomite, resembling the yellow magnesian

* Memoirs of the Geological Survey, vol. i.

† The New Red Sandstone formation in this area is composed of three members:—1, the Dolomitic Conglomerate; 2, the New Red Sandstone; 3, the New Red Marls at the summit.

limestones of the N.E. of England. At Yate Rocks, near Yate and Chipping Sodbury, the yellow conglomerate, similar in all its conditions to that of Clevedon, rests upon the upper beds of the Carboniferous Limestone and Millstone Grit, assuming the most step-like character (*c* in fig. 1). The edge of the underlying limestone, (*a*), is denuded to a perfect plane by the agent which deposited the conglomerate.

Fig. 1.—*Section at Yate Rocks.*



a. Carboniferous Limestone. *b* & *c.* Conglomerate.

This locality exhibits the only remnant of the yellow magnesian beds known in the northern part of the Bristol coal-field. They must, however, have extended along the whole of the eastern side of the basin, from Wick Rocks to Cromhall, where a similar solitary patch attests its northern extension. North of Cromhall, at Tortworth, the conglomerate follows the curve and strike of the Old Red Sandstone and Lower Limestone Shales. I cannot doubt that the yellow beds of Yate Rocks might be exposed in many other places by the removal of the Trias and overlying Lias.

4. Geographical Distribution of, or Area occupied by the Dolomitic Conglomerate.

The palæozoic rocks of the Bristol coal-field, ranging in time from the Caradoc sandstone to the close of the coal-measures inclusive, are more or less indiscriminately covered by patches of this conglomerate at various heights, from 20 feet to 350 feet above the level of the sea. These rest either upon the Silurian, Devonian, or Carboniferous series, and are the result of that marine denudation which took place during the later Bunter or the commencement of the Keuper deposits.

The Bristol coal-basin occupies an area of about 600 square miles, or a tract of country 30 miles long by 20 wide; and everywhere within this area, either fringing or capping at intervals the oldest rocks, does the dolomitic conglomerate occur.

Its northernmost limit is at Tortworth; and its most southerly extension is outside the limits of the basin, or south of the Mendips, at Worminster and West Compton, the whole equalling a distance of 32 miles, and having masses more or less exposed along the whole western side of the coal-field. The north and south flanks of the Mendips are both continuously fringed and partly covered by beach-like masses varying from 20 to 50 feet in thickness, and in places ascending to the very summit of that range of hills, as at Shipham, North Hill, and Haydon, at Blagdon, East

Harptree, Chewton Mendip, Stratton on the Fosse, Mells, and Elm on the north side, where it is a grand and significant feature in the physical structure of the flanks of the Mendip chain. In the words of De la Beche, "Standing on any of the high grounds on the Mendip Hills, it is interesting to consider how exactly the masses occur as they should do, under the supposition that they have been beaches among islands rising above the sea of the time."

Again, at Croscombe, Dinder, Wookey*, Westbury, Cheddar, and Compton Bishop it exhibits itself as a portion of a widely spread series to the south of the Mendips, beneath the Keuper and Lias of the plain of Somerset. The singular outliers of Gambarts Hill, Worminster, Knowle, and Church Hills south-east of Wells, islands of Carboniferous Limestone, now surrounded by dolomitic conglomerate and Red Sandstone, are evidences of what must be the deeper-seated condition of these beds under the plain of New Red and Lias of Pennard and Glastonbury on the south, onwards to South Devon, extending, as I believe, to, and being of the same age as, the conglomerate, breccia, or pebble-beds of Budleigh-Salterton, and the sandstones containing *Hyperodapedon*.

I cannot, also, doubt that the remarkable breccias on either side of the Quantock Hills and in the vales of Stogumber and Wellington, which follow the tortuous course of the flank of the Exmoor, are all of this age.

I must not omit to notice the remarkable outlier of Broadfield Down, between Bristol and the Mendips; for at no point around its island-like mass is it free from this encircling, reef-like, or fringing conglomerate. To attest still more its widely spread condition, I must also assert its continuous presence at the base of the Lower Secondary rocks which cover up, or conceal, the coal-measures of the Somersetshire coal-field, or that area occupied by these rocks between Bristol and the Mendip Hills, in a north and south direction, as well as east and west from Broadfield Down to Newton St. Leo, near Bath, thus giving an area of 140 square miles, the greater portion of which is, I doubt not, occupied by *unexposed* dolomitic conglomerate, generally or universally known and designated by the coal-miners as the "overlie," or "millstone," from its invariably occupying the same position below the Keuper series over the southern area, and covering the several members of the coal-measures (the Upper Coal-shale, Pennant, and Lower Coal-shale). In the narrow vale of Wrington, at Butcombe, between Winford on Broadfield Down and Blagdon at the north part of the Mendip Hills, it is also finely exposed, the superincumbent hills of Lias and Red Marls being cut down or denuded so as to expose the conglomerate.

Nowhere along the eastern side of the southern basin, *except at* Mells, at the S.E. or E. extremity of the Mendip range, are these rocks exposed or brought to the surface; but here they conceal the junction of the coal-measures with the mountain-limestone abutting

* The famous Hyæna-den and cavern of Wookey Hole are both excavated in this conglomerate.

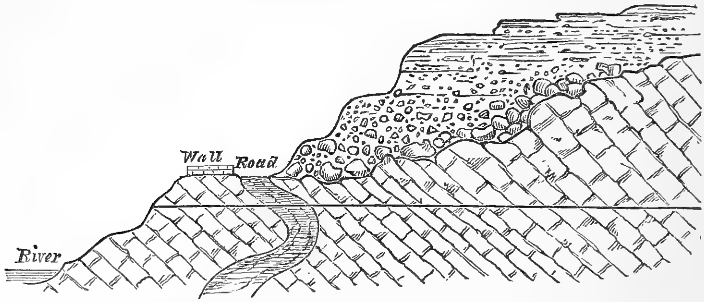
against and forming the gorge of the Nettlebridge River in steep mural precipices 50 feet high, and composed of boulders or fragments tons in weight.

No valley to the N.E. of Mells is cut down sufficiently deep through the overlying marls, Lias, and Oolites to expose the breccia; but its presence at Wick, north of Bath, on the one hand, and at Mells, before named, on the other, clearly proves that the removal of the superincumbent secondary strata ranging from the New Red to the Great Oolite inclusive would reveal it.

The northern part of the Bristol coal-basin, or that portion ranging from Bristol, Holy Trinity, and Wick, on the south, to Cromhall and Tortworth, on the north, possesses on its eastern, northern, and western sides abundant evidence of this once continuous conglomerate *within* the basin; but now, owing to the removal of all the overlying newer or mesozoic rocks from the centre of the coal-field, and the exposure of the Upper Coal-measures and Pennant sandstone at Coal-pit Heath, Yate, &c., its presence is only indicated by extensive and continuous patches resting on the high ridge of land occupied by Tytherington, Olveston, and Almondsbury, and on to the tableland around Henbury, Leigh Downs, and Clifton, all on the western side of the north basin. The accompanying diagram (fig. 2) exhibits the characteristic condition of the Breccia, and is a carefully prepared illustration of the well-known mass overhanging the river Avon on its right bank, and about 200 feet above the river; this, with many others, shows the gradual passage into finer breccia and pebbles, and ultimately into the fine-grained sandstones which cover up the Clifton Downs west of the Observatory, and the tableland to the north. This isolated mass, with other evidence on both banks of the Avon, at and above the same level, clearly determines the age of the gorge of the Avon to be Post-Liassic in time, and shows that the river must have cut its downward or deepening channel through a large amount of superincumbent Secondary rocks; for from the sea-level, at Portishead and Pill, &c., up to the height of the reptilian conglomerate on Durdham Down, we have a constant succession of these beds resting upon the older rocks of the river, and here and there clinging to the precipitous faces of Carboniferous Limestone or Old Red Sandstone rocks that constitute the gorge of the tortuous Avon, and finally spreading themselves under the finer sandstone of the Keuper over the great mass of Carboniferous Limestone, &c., that constitutes the heights on the western side of the coal-basin, 300 feet above the sea.

Crossing the channel we find the same phenomena existing between Tidenham near Chepstow, and Pyle near Bridgend, to the west. Its northern range is defined and bounded by the southern outcrop of the Carboniferous Limestone and Coal-measures of the South-Welsh coal-field, where, as in Gloucestershire and Somersetshire, it rests in patches upon the older rocks, and, as on the eastern side of the Severn, is the source of the calamine, lead, and hydrated oxides of iron of the South-Wales area.

Fig. 2.—*Section of Dolomitic Conglomerate in the new road leading from the Hotwells to Clifton and Durdham Downs, showing passage from heavy massive Conglomerate into fine-grained Sandstone.*



This breccia largely occupies the country between Barry and Sully Islands and Llandaff, and between the latter place and Llanharry, Coyty, and Pyle, fringing the limestone downs of St. Nicholas, St. Donats, and Nottage, and is, in extent, nearly equal to that of the Mendip range; indeed, physically, these two masses of old land on either side of the Severn were, and are now, one, being divided only by a deep depression in the Carboniferous Limestone, now occupied by the waters of the Severn. The strike of the submerged limestone is still indicated by three patches at Barry Island, the Wolves' Rock, and the two islands termed the Flat and Steep Holmes, which now evidence that the ridge of high palæozoic land was once continuous to the peninsula of Gower and Menevia, and onwards, under the St. George's Channel, to the south of Ireland. This axis alone is determinable for 150 miles, over nearly 80 of which the conglomerate occurs more or less, covering much of the once-exposed masses and flanks of the older rocks.

In the Bristol area, however, as noticed by Buckland and Conybeare *, the breccia is chiefly composed of the *débris* of the rocks on which the conglomerate rests; and the fragments vary in size from an inch to three or four feet in diameter, many of the larger boulders weighing from one to three tons each.

The conglomerate of the Quantock Hills (of the same age) is constructed entirely of the Devonian slates and limestones of which these hills are composed; so with the breccias at Milverton, east of Wiveliscombe, and in the vale of Stogumber, between the Quantock Hills and the Exmoor. Porlock and Luckham valleys, although so completely isolated and shut in and to the north of Exmoor, exhibit conglomerates of the same age, and have the same physical aspects. So also at Brandon Hill (Bristol), where pebbles of quartzose millstone grit only form the mass. On the left bank of the Avon, opposite Cook's Folly, the conglomerate conceals the subjacent highly inclined beds of Old Red Sandstone, and is there also entirely derived from the rock upon which it rests.

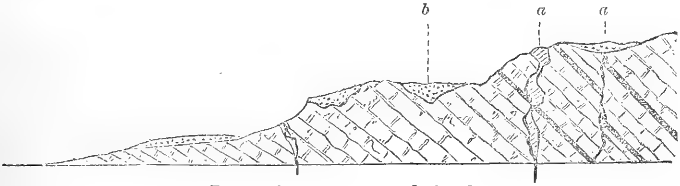
* Trans. Geol. Soc. vol. i.

5. Influence of the Conglomerate upon the production of Minerals.

The well-known rich deposits of calamine (carbonate of zinc) once extensively worked at Shipham, Burrington, Rowborrow, Chewton, Priddy, and Heydon, on the Mendip Hills, occurred chiefly in the mass of the dolomitic conglomerate itself, but also in faults, fissures, and hollows, or pockets, in the Carboniferous Limestone, which were present prior to the deposition of the conglomerate and New Red Sandstone, subsequently filled in by the same, and influenced during deposition. So also with the rich deposits of hydrated peroxides of iron, or brown and red hæmatitic iron-ores, over and around the entire coal-basin; for nearly everywhere where the conglomerate rests upon the Carboniferous Limestone, Pennant, or Millstone Grit do these brown and red hæmatitic iron-ores exist. The area occupied by the breccia due west of Bristol, and on the south-west side of the Avon, has always been remarkable, and one of interest to the mineralogist. The rich hæmatite-ores of Clapton in Gordano, Providence Place, and Ashton, the geodes &c. on the flanks of Leigh Down, the quartz crystals (Bristol diamonds) and strontia &c. are everywhere associated with the conglomerate when it rests on the older rocks before mentioned.

Nearly all, if not all, the iron-ore in veins or faults in the Carboniferous Limestone, Millstone Grit, and Pennant were filled in at the time when the conglomerates were being developed and deposited, and these older rocks denuded away by the Keuper sea. So with the ores in pockets, where the carbonate of lime and magnesian

Fig. 3.—*Section showing mode of occurrence of Iron-ores in Carboniferous Limestone &c.*



a, a. Iron veins. *b.* Pocket.

cement has been removed or replaced in many or most instances by the infiltration of the oxides of iron, &c., since the deposition of the conglomerate. Few inquiries are more interesting or more important than that into the relation which mineral veins hold to the rocks which enclose them or with which they are intimately associated*.

It is well known that the whole of the palæozoic rocks in this area, as in others, were placed in their disturbed position prior to

* The ores of zinc and lead may have been derived mechanically from previously existing metalliferous veins which traversed the Mountain-limestone. Yet, on the other hand, the Zechstein and Alpine limestone are highly metalliferous, and they would appear to be in part the foreign equivalents of the dolomitic conglomerates of England.

that long period of denudation which was ushered in with the commencement of the Bunter, and succeeded by the Keuper.

It was during this period that the destruction and removal of the bolder masses of the palæozoic rocks took place, and this during their depression to great depths in the New-Red ocean, thus producing the accumulated masses of the dolomitic conglomerate, associated sandstones and marls, and added to these the superimposed Lias &c. This depression must have gone on to the extent of some 4000 or 5000 feet*, physical and cosmical changes again (or subsequently) bringing to the surface the old palæozoic land under newly modified conditions; and during this slow and gradual emergence the Trias, Lias, and Oolitic rocks were in their turn denuded and swept away, thus giving to the Severn area and valley the general physical features and aspects now presented to us.

We thus have to do with phenomena belonging to *two* distinct and extended epochs of time,—the *first* being the removal and remodelling of the prior-existing older and newer palæozoic rocks, through the advent of the Mesozoic period, and by the agency of the Permian and Triassic seas (which cut back and denuded the coast-lines then exposed to their influence), and the deposition in the deeper regions, and along the strike of the shores, of the spoils of the older continent.

The second epoch was that later, even almost modern period of geological time when by the reelevation or reemergence of the accumulated secondary rock-masses, and their subsequent removal, the old surfaces, if not still deeper ones, became again exposed and remodelled, assuming fresh geographical outlines dependent upon the amount of oscillation the land then underwent in relation to the stability of the ocean-level. Thus many of the fissures and faults in the palæozoic rocks have been twice exposed and influenced, and through great periods of time; and no one can witness the remnants of some doubtful Permian and Triassic rocks which rest upon the higher lands occupied by the Carboniferous Limestone and Millstone Grit of the district, or examine the mineral veins, fissures, faults, and joints, and their mode of occurrence, without being strongly impressed, if not convinced, that the conditions thus briefly noticed are those which bear out the hypothesis I have enunciated to account for the accumulation of the ores of iron and zinc, sulphate of strontia, and occasionally manganese. An example of this remodelling of the very same conglomerate is now exhibited along the eastern shores of the Severn between Portishead and Clevedon, where the waters of the estuary are now daily, constantly, and effectually removing its barrier of magnesian breccia, as well as the underlying mountain-limestone, Pennant, and Old Red Sandstone, and again reconstructing the whole into a quaternary conglomerate or modern breccia, but with a different cementing constituent.

I am inclined to believe that this later period of denudation must have occurred during the lengthened era of the Miocene or later

* The Bristol coal-field is between 5000 and 6000 feet deep.

tertiary times—and cannot doubt, from the physical condition of the vales of the Severn, Gloucester, and Berkeley, &c., that the finely exposed western escarpments of Oolite, and still more eastward ranges of Cretaceous rocks, in fact the whole Secondary series, once covered and arched over the now deeply exposed and denuded Lower Mesozoic and Palæozoic rocks that constitute the mass of the country west of the Cotteswold range. What influence and changes these valleys underwent still later, or during the Pliocene and Post-pliocene epochs, I would leave to be discussed in a special paper upon the age of the Severn valley.

I believe, then, that it was during the progress of the denudation of the palæozoic rocks by the seas of the Triassic epoch that the pre-existing faults and fissures, or open joints, &c., along the coast-lines, were mechanically and chemically filled in. The colour and nature of the New Red marls and sandstones, fully attest the presence and abundance of the peroxide and protoxide of iron at the time of their deposition, due perhaps originally to the oxidation of the materials contained in the older carboniferous rocks, which became thus metamorphosed during removal and deposition. The chemical condition of the saline waters, or even water at a higher temperature than that of the modern seas of Europe, may have tended to the more rapid deposition or accumulation of the iron &c. in the faults and fissures.

There are many localities in and around the Bristol coal-field where full and complete evidence can be obtained as to the age of the infilling of these dislocations &c. in the Carboniferous Limestone, Millstone Grit, and Pennant, due to the destruction of the older rocks by that sea which also deposited the conglomerate and associated New Red series.

At Broadfield Down, south of Bristol, Providence Place, near Ashton, many places on the Mendip Hills, as well as north-west of Bristol, along the west side of the coal-basin, where the hydrous oxides of iron are worked, the broad and exposed surfaces of the limestone and grits are planed away and laid bare; and here and there in the depressions pockets occur, the remains, or remnants, of the earliest-formed portion of the dolomitic conglomerate. So also with the fissures and faults which are usually filled with the magnesian breccia, the cementing matrix in many cases being the brown and red hydrated peroxides of iron as well as the dolomites, the qualities and quantities of the ore differing with the matrix or rock in which it occurs. Doubtless the percolation of water through porous overlying strata highly charged with the oxides of iron, as is the case with the New Red series, has also been a source and mode of accumulation; and this phenomenon or mode of production is now in operation along the lines and in and upon the walls of the great Ram Hill and associated fault that traverses the northern coal-basin, as, notably, at Frampton Cotterell.

It is, however, to Clifton that my paper has chief reference, as I am desirous of fixing the exact position of the locality where the remains of *Thecodontosaurus* and *Palæosaurus* were discovered by

Messrs. Riley and Stutchbury in the year 1836, the additional interest now attached to these remains being due to fresh researches, by Prof. Huxley, into the history and distribution of the Dinosauria through the lower Secondary rocks of the globe. It therefore becomes a matter of interest, if not necessity, to fix the geological age of the reptilian remains—the more so, in this case, on account of the numerous opinions held by Continental and British geologists as to the exact equivalents of this conglomerate, and its place in the Triassic group.

6. Position in time of the Reptilian or Dolomitic Conglomerate.

It is at all times difficult, if not, perhaps, almost impossible, to assign an approximate age to remains found in an extensive, continuously and contemporaneously forming and associated conglomerate belonging to any age or deposit; it is especially so with the Dinosauria under consideration; and whether they inhabited any certain or given area, or at any given period during the immense lapse of time these magnesian breccias were under accumulation, is a problem important to solve, both as to space and time,—the first as bearing upon the habitat, locality, or area occupied by these genera prior to, and at the time of their deposition; the latter as affecting their relation to that particular horizon of the conglomerate, and the assignment to these remains of an *early* or late date in relation to the mass. Two great periods of oscillation and associated phenomena have been assigned to the area under notice,—the first a downward movement of the palæozoic land with its consequent loss of material, which must have commenced after its consolidation and elevation to the position it occupied at the time the New-Red sea began to denude its mass, and lasted through the whole of that long period of depression which was sufficient to allow of fully 1000 feet of New Red marl and sand to be deposited over the depressed palæozoic rocks. The second period was one of elevation, during which the accumulation of the first period was again partly, if not almost entirely, denuded or removed (*this is of comparatively recent date*); and this again exposed the old land-surfaces, nearly as we now see them. Certainly, then, at some period during the depression and accumulation of the dolomitic conglomerate these reptilian remains were deposited; and it is equally certain that these two genera (*Thecodontosaurus* and *Palæosaurus*) inhabited the area or region where found.

The occurrence of these Triassic Dinosauria at the elevation of 300 feet above the present sea-level, and on the general tableland now occupied by the Carboniferous Limestone, and apparently that portion of it last influenced by the New-Red sea, would lead me to infer that it was late in the history of the Keuper that *their* deposition was effected. I assume this from the different stages and relative levels now occupied by the conglomerate, which necessarily elucidate their position in time at the date of deposition. The whole period of elevation is measured by the successive steps and stages occupied by

this breccia deep under the plain of New Red (below the present sea-level) and overlying the coal-measures of the Somersetshire coal-pits. At Clevedon and Portishead it *now* fringes the sea-margin resting on Old Red, Carboniferous, and Pennant, whilst at Clifton, the Mendip Hills, the north part of the coal-basin, and numerous other spots, it occupies intermediate geographical sites, thus clearly showing a depression and reelevation of at least 1000 feet. During the whole of this amount of oscillation and accumulation of the Keuper marls and sandstones in the deeper portions of the sea, the conglomerates were forming along the margins, shallows, and shores of the palæozoic land. These Dinosauria, then, from their place in time, or the elevated geographical locality they now occupy (which in this case is a measure of time), would appear to have lived during the later portion of the deposition of the Keuper; be it remembered, however, that we have no proof of the Bunter beds ever having been deposited over the Bristol area. There is nothing whatever to show that these Dinosauria did not occupy this area, and live through the whole of the Triassic epoch. The chief difficulty is the realization of the affinities of these reptiles to any preexisting forms through the doctrine of evolution—as well as the area or province occupied by them, or from which they may have migrated. The question becomes one of the distribution of dry land during Prætriassic time, and also whether that land was occupied by Dinosaurian and Lacertilian types differentiated through descent during the lapse of time that occurred or was represented between the Palæozoic and Mesozoic epochs. The limited area occupied by this peculiar conglomerate over the Bristol district, and the paucity of remains occurring in it, added to the fact that those found were evidently not deposited during its early deposition or history, render it doubly difficult to come to a conclusion or even hypothesis as to the probable distribution of these Dinosauria in time.

7. Zoological Contents or Fauna of the Dolomitic Conglomerate.

With the exception of a few fossils derived from the Carboniferous Limestone and Millstone Grit *, upon which the conglomerate rests, only a few reptilian bones belonging to two genera have been discovered and assigned to the age of the conglomerate. These remains were first noticed and described by Dr. Riley and Mr. Samuel Stutchbury, of the Bristol Philosophical Institution, in the year 1836 †, and were then the oldest known Dinosauria in Britain. These authors referred them to two reptilian genera *Thecodontosaurus* and *Palæosaurus*, noticing their Megalosauroid affinities through the characters of the vertebræ and femora. Subsequent examination of these remains by Prof. Huxley has clearly established their true

* Spirifera cuspidata.	Chonetes hardrensis.	Cochliodus contortus.
—— striata.	Productus.	Lithostrotion junceum.
Terebratula hastata.	Psammodus porosus.	—— irregulare.

† Geol. Trans. vol. v. 2nd ser. p. 349.

nature and affinities with the Dinosauria, as based upon certain parts of the skeleton, especially the "caudal vertebræ, chevron bones, ilium, and tibia" *. These two genera are assigned by Prof. Huxley to two distinct families, the Megalosauridæ and Scelidosauridæ—*Palæosaurus* being placed with the Megalosauroid, and *Thecodontosaurus* with the Scelidosauroid type.

Their remains were found in a mass of dolomitic conglomerate on the eastern side of Durdham Down, near Clifton, Bristol. The whole being in a very fragmentary state, as might be anticipated from the nature of the matrix in which they were entombed, the most extreme care was bestowed both upon the removal of the dismembered fragments and their subsequent development, as now exhibited in the Museum of the Bristol Philosophical Institution.

The spot where these remains were found is no longer recognizable or determinable, having been many years ago quarried away, and the site built upon. Fortunately, however, we have records of the exact position; and many years since, W. Sanders, Esq., F.R.S., of Clifton, during a careful geological survey of the city of Bristol and its suburbs, undertaken for the Inspectors of the General Board of Health, most accurately determined the site of the reptilian quarry on the eastern side of Durdham Down (figs. 4 & 5).

Fig. 4.—*Section from the city of Bristol to the Reptilian Quarry on Durdham Down, 320 feet above mean sea-level, showing the position of the Conglomerate upon the Coal-measures, Millstone Grit, and Carboniferous Limestone, and the Lias resting on the New Red Marls and Sandstone.*

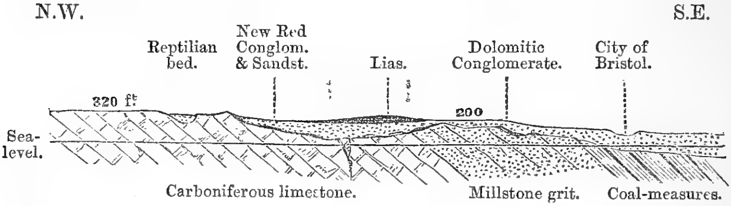
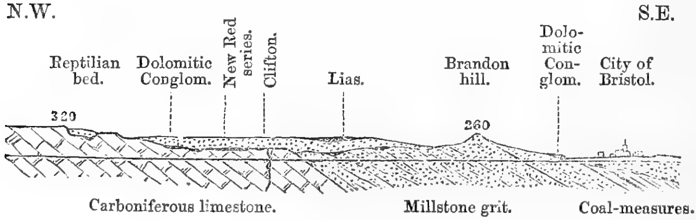


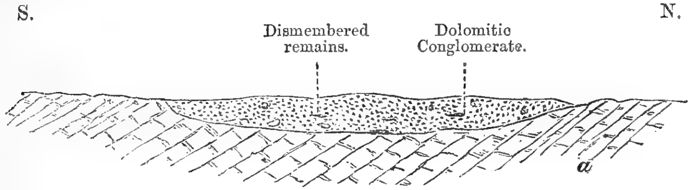
Fig. 5.—*Section from the city of Bristol, across Brandon Hill, 260 feet above the sea, to the Reptilian Quarry, 320 feet, on Durdham Down in the Carboniferous Limestone.*



* Quart. Journ. Geol. Soc. vol. xxvi. pp. 42–45.

My friend Mr. Samuel Stutchbury many years ago also furnished me with the accompanying sketch (fig. 6) of the beds of conglomerate during the period the remains were being removed.

Fig. 6.—*Position of Reptilia in the Conglomerate of Durdham Down.*



a. Carboniferous limestone.

I may mention that several of the bones were in actual contact with, or resting upon, the carboniferous limestone; whereas others, and the majority, were or distributed between one and two feet above the junction of the solid brecciated conglomerate with the limestone below.

The boulders were chiefly subangular, many of great size, and evidently had not been far removed from their parent source in the Carboniferous Limestone.

It was quite evident, from the condition and position of the remains in the breccia, that they must have been dismembered prior to their final deposition; for many of the bones were much fractured. This is especially the case with a lower right ramus, which is fractured into three pieces; and the vertebræ in some instances are much worn or mutilated; so with the coracoids, tibia, and fibula, &c. I, however, abstain from entering into any particulars about these reptilian remains, and refer for such information to the researches of Prof. Huxley (*loc. cit.*).

8. Stratigraphical Relations of the Dolomitic or Reptilian Conglomerate to Continental Deposits.

The equivalence of this peculiar breccia, outside the region or area to which it appears to be confined, is not a matter of easy solution even in our own country.

Regarding its position stratigraphically, it may occupy the place of the Muschelkalk, a formation wanting (so far as we know) in the British islands*. In *time*, therefore, it may be, and probably is, the equivalent of this missing member of the Trias; but the highly fossiliferous condition and extensive fauna of the Muschelkalk, as exposed in Northern and Central Germany, contrasted with the barrenness of this conglomerate, and perhaps also of the calcareous breccia and conglomerate of the Midland Counties, afford us no

* The Bunter series does not appear to have been deposited in the Bristol area.

real *clue* for correlation on palæontological grounds—affinity only, through a few species in that richly peopled sea, being shown by *our* succeeding Rhætic beds.

It is not, however, without interest that we *should reexamine* the Sutton, Portcaul, Bendrick, and Barry beds, on the coast of Glamorganshire, where St.-Cassian and Muschelkalk types occur in a white calcareous breccia or conglomerate resting immediately upon the Carboniferous limestone and below the zones of *Ammonites angulatus* and *A. planorbis*.

The Madreporaria are truly significant, and of high Mesozoic antiquity, even admitting the great vertical range or persistency of many St.-Cassian corals in time and their diffusion in space.

Chronologically, however, we have much to learn relative to the true succession and correlation of the Triassic and Rhætic series of this country with reference to that of Western and Central Europe.

On purely physical grounds we have also much to do ere we can attempt to parallel the Muschelkalk (Calcaire Coquillien) with beds in the western or midland counties of England, although we may attempt it, and look for its equivalent in the calcareous breccia or conglomerate at the top of the Bunter, and base of the Keuper series in the centre of England—the position in time held by the dolomitic or reptilian conglomerate of the Bristol area.

That the calcareous breccia above mentioned should be classed with the Keuper rather than the Bunter is, I think, clearly established.

The chief explanation, however, of the probable reason of the absence of the Muschelkalk in Britain would appear to be the received fact that the "close of the Bunter-Sandstone period in England was accompanied by a general elevation into dry land of the whole of the Triassic area, in which condition it remained throughout the period of the Muschelkalk"*,—this gap, unconformity, or break in the British series of the Trias, being represented on the Continent by the highly fossiliferous "calcaire coquillien," or Muschelkalk.

Mr. Hull throws out the suggestion † that the St.-Cassian beds, which contain so large an assemblage of organic remains, both of Palæozoic, Mesozoic, and peculiar forms, in somewhat abnormal positions, because there is still some uncertainty regarding their affinities to the British series, may not improbably, in different portions, "represent a continuous series of calcareous deposits, representing both the Permian, Triassic, and Rhætic beds of England."

The absence, however, in the dolomitic conglomerate of the Bristol area, of all organic remains except the two genera of Dinosauria, and those at present confined to it, forbids all attempts at correlation based upon palæontological research.

* Hull, Mem. Geol. Surv. England and Wales, "Trias. and Perm. Rocks of the Midland Counties," 1869, p. 106.

† Ib. p. 9.

9. Table of the Classification of the British Trias, and its Foreign Equivalents, from the Rhætic series downwards.

		Foreign equivalents.
TRIASSIC SERIES.	A 1. Rhætic, or Pennarth beds, finely exposed at Pennarth, Watchett, Westbury, Aust-passage, Uphill, Minlode, Coombe Hill, &c. &c.	Die Kössener Schichten.
	A 2. New Red Marl. Red Marls with bands of grey marly clay, occasionally micaceous, and numerous lenticular masses and veins of Gypsum and Rock Salt *. Bivalve crustacea (*Estheria*). Rhizopoda in Leicestershire, at the base, at its junction with the Keuper Sandstone.	Keuper. Marnes Irisées.
	A 3. Keuper Sandstone. Laminated Sandstone, and interstratified Marls (water-stones), passing down into (variously coloured) pale and deep-red Sandstones. *In the centre of England it has a calcareous conglomerate or breccia at the base.* In the west of England this *appears* to be replaced or represented in time by the Dolomitic or Dinosaurian conglomerate which covers the older rocks of the Bristol coal-basin.	Letten-Kohle.
	B. Muschelkalk or Calcaire coquillien (?), wanting in England, unless represented by the Dolomitic Conglomerate.	Muschelkalk. Calcaire coquillien.
	C 1. Upper Mottled Sandstone. Soft bright-red and variegated sandstones (without pebbles). C 2. Pebble-beds. Harder reddish-brown sandstone, with quartzose pebbles, passing into conglomerate, with a base of calcareous breccia. C 3. Lower Mottled Sandstone. Soft bright-red and variegated sandstones without pebbles.	Bunter Sandstein. Grès bigarré, or Grès des Vosges (in part).

Permian.

Discussion.

The President inquired on what ground the author considered these Reptiles to belong to a late period in the Keuper, and was informed that the author spoke especially with relation to the Keuper of the Bristol area, of which the beds containing them occupied the highest position.

Prof. Ramsay regarded these conglomerates not merely as of aqueous origin, but as breccias which had covered the old land surface which had been worked up by the water of the New Red period. He objected to the term Sea having been introduced into the paper, as, though the tracts may have been islands and promontories, and though the water which surrounded them was salt, there was no open sea, but merely a large inland salt lake, in which the New Red Marl was formed. The marl was less connected with the New Red Sandstone than with the Lias. The Muschelkalk being absent,

* None in the Bristol area.

it was constantly the case that the marl rested immediately on the palæozoic rocks without the intervention of the Bunter Sandstone. He thought that there were good grounds for connecting the Rhætic beds with the New Red Marl below and the Lias above. The probability was that the change in character was due to a gradual influx of the sea into the inland lakes. He thought that the Thecodont Saurians might also eventually be found even in beds of Liassic age.

Prof. T. Rupert Jones remarked that Mr. Tawney and Dr. Duncan had already intimated the St.-Cassian aspect and character of the Sutton beds. The freshwater character of some of the Keuper beds was, he remarked, indicated by the presence of *Estheriæ*; and he alluded to the fact of the Bristol Palæosaurians having been erroneously used as Permian characteristics in Russia and Carolina.

Mr. W. Boyd Dawkins had found at Cheddar that the Dolomitic Conglomerate formed two great tongues running up ravines in the older rock, which had probably been due to subaërial action.

Prof. Morris alluded to some sections which seemed to corroborate the views of Mr. Etheridge, and pointed out the relation of the Conglomerate beds to the overlying strata at those points. He also mentioned certain peculiarities in the structure of the conglomerate itself.

Mr. Etheridge stated in reply that the Marls in the Bristol area were the exception, the greater part of the New Red beds being sandstone.

---

2. *On the* Surface-deposits *in the* Neighbourhood *of* Rugby. By J. M. Wilson, Esq., M.A., F.G.S., Mathematical and Natural-Science Master in Rugby School, late Fellow of St. John's College, Cambridge.

I believe no detailed information about the surface-deposits in the neighbourhood of Rugby has been communicated to this or to any Society; and I therefore offer the following observations, which fall under two heads:—

(1) The surface-deposits of the high levels.

(2) The deposits in the valleys.

In the present paper I confine myself strictly to facts for which I hold myself responsible as resting on my own observation, or on information obtained on the spot on which I can rely.

Physical Geography.

There is a plateau of irregular shape, of which the southern edge is well defined, on which the villages of Bourton, Thurlaston, Dunchurch, and Hillmorton are placed. From this line, which faces S.S.E., the eye ranges over the wide valley of Birdingbury, Granborough, and Willoughby. The height of the plateau above the level of the valley is about 120 feet. The plateau has a slight slope

towards the N.N.W. The heights of points nearly equidistant along the Hillmorton, Dunchurch, and Avenue roads are in succession 403, 400, 400, 400, 392, 375, 370 feet above the sea, indicating a slope westward, while the heights 396, 382, 378, 355, on the Dunchurch, Rugby, and Clifton roads, indicate a still more decided slope towards the north.

The southern edge of this plateau is well defined. The north-eastern edge, which forms the southern flank of the Avon valley, is less regular, though nearly equally steep. It is broken by a succession of lateral valleys which contain tributaries to the Avon. The village of Lowmorton occupies such a lateral valley; another is crossed by the Lowmorton and Rugby road; and an important valley is crossed at the Victoria works near Rugby, and by the Bilton road between Rugby and Bilton.

Nature of the subjacent Strata.

The whole of the district under examination is Lower Lias, with the exception of a few patches of Middle Lias towards the south-east. The limestones and clays of the Lower Lias are well developed, and abundantly exhibited in large lime- and clay-works; and an admirable section of them has been the only profitable result of an artesian well of 1145 feet depth. The lie of the hills and valleys appears to be totally independent of the distribution of the clays and limestones; the limestones do not form the escarpments, nor do the clays determine the paths of the rivers; the geological skeleton and the actual contour have no obvious and immediate connexion with one another.

Detailed Account of the Surface-deposits on the Rugby Plateau.

At *Bourton* the soil is generally gravel and sand like that at Rugby, 12 or 13 feet in thickness, reposing on clay. At about 30 feet depth the limestone rock is reached. This, as is pretty obvious from an inspection of the map, and a knowledge of the general strike of the strata, is the continuation of the Newbold limestone, and it does in fact come to the surface at the foot of the escarpment at Draycote, immediately below Bourton. One well at Bourton is 90 feet deep, 60 feet of it being in the rock.

The same general character continues along the escarpments to *Thurlaston*, which village rests on gravel of the same or greater thickness. In two places, however, there are wells 50 deep feet, which of course indicate that the depth of the gravel there is insufficient to supply the surface-wells with water. At Thurlaston the limestone rock is not reached; some thin bands of it which lie interstratified with the clay are passed through.

At *Dunchurch* the surface-deposits are precisely the same. I have not been able to hear of any deep wells. The gravel and sand are generally about 13 feet deep. At Mr. Harrison's house, on the brow near Bilton Grange, there are three wells—two in gravel, of 13 and 14 feet, and one in clay, of 30 feet. At Bilton Grange the depth of

the gravel varies much, from 6 feet upwards; and all the way to Hillmorton the same remark is true. On the whole it deepens towards Hillmorton; but an inspection of the ponds shows that there are many places where the clay nears the surface.

At *Hillmorton* we come upon the most interesting spot in the whole neighbourhood. The gravel along the upper road averages 14 or 15 feet, thinning out on the slopes on all sides. At the toll-gate, on the slope leading to Kilsby, it is 8 feet. At Mr. Darnell's, which is at the head of the little lateral valley leading to Low Morton, it is 13 feet. At the Hillmorton clay-pits it can be seen to thin out down the slope of the hill from 6 to 3 feet or less. In sinking Mr. Darnell's well, there was found below the gravel a stiff sandy soil, wet, with streaks of white and red clay, then a stiff blue clay containing chalk-pebbles, 3 or 4 feet in thickness, and finally blue Lias clay containing nodules of limestone. The largest of the chalk-pebbles was about $1\frac{1}{2}$ inch round. The well was sunk 42 feet, and the boring continued 62 feet.

The ground slopes on all sides down to the narrow valley in which *Lowmorton* stands; the street that leads to Hillmorton occupies nearly the whole width of the valley. The gravel thins out down the slope, and entirely disappears just above the lower village; the surface-soil there rests on undisturbed Lias clay. On the sides and bottom of the valley are very large accumulations of sand, which form perhaps the most striking feature in this neighbourhood.

On the left-hand side of the valley is a large sand-pit with a clay-pit just above it. In the upper pit flinty drift is seen to overlie interstratified sands and gravel-beds to a depth of about 10 feet. The lower sands are not distinguishable from the sands of the sand-pit, with which they are evidently continuous. There are here several small faults in the sand: I ascertained by excavation that they passed down into stiff reddish greasy clay that lies under the sand and over the Lias clay. Seams of the same clay are found in the upper part of the sand-pit. The sand has a thickness of at least 47 feet, and is thrown against a remarkably steep bank of Lias clay. This must have a slope of not less than 45°.

The *Sand-pit* forms an amphitheatre 47 feet in height. It is a sugary dirty sand containing about 5 per cent. of chalk and sesquioxide of iron, according to an analysis made by Mr. W. H. Pike in the School laboratory. The sand is stratified, and contains a few thin layers of black carbonaceous matter resembling coal. It contains a few small pebbles of flint and quartzite; and in the streaks of fine clay are nodules which contain some lime and a few rolled specimens of *Gryphœa incurva*.

The sand skirts the whole northern edge of the plateau before spoken of, and is shown at the cutting on the Rugby and Lowmorton road. It extends about half a mile towards Rugby, thinning out up the slope, where the clay comes to the surface. At Low Morton itself the valley is filled in its lower part with sand, and the east as well as the west slopes have large sand-banks. In some places it is exposed, covered with clean flinty gravel. But it is best exhibited

in the *Ballast-pits.* The cliff to the west exposes a fine section of the prevailing flinty drift overlying this sand. The edge of a terrace visible there is the same steep slope of Lias that was spoken of above. Masses of clay still lie about the ballast-pits. These formerly overlay the sand in detached spots. They are re-formations of Lias containing pebbles of lias, oolite, and chalk, with many flints and much quartzite; some of the pebbles are striated. There was one heap of clay, a yard or so across, which yielded totally different specimens, and perplexed me much. I found afterwards that it had been brought for some reason from beyond Blisworth.

The sand here frequently exhibits diagonal stratification; it contains small pebbles of flint, oolite, chalk, quartzite, and rolled Lias fossils. I have been informed that Mr. Searles Wood found *Ostrea edulis* here. Many of my pupils and I have spent hours here; and no shells or bones have ever been discovered by us, or noticed by any workmen, as far as I can ascertain.

From Rugby to Lowmorton there is generally 13 feet of gravel lying on clayey sand. Towards the northern edge of the plateau the gravel thins out; and here a cutting of the London and North-western offers a magnificent section of the clays below the gravel and sand. The cutting is 50 feet in depth, and exposes a re-formation of Lias clay containing scratched stones. I have met with well-striated blocks of liassic limestone, of chalk, and flint. The clay is wholly unstratified, very soft and wet. The whole depth, except a few feet of gravel and sand at the top, appears to be of the same nature.

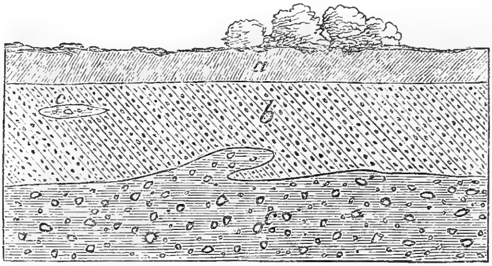
The deposit disappears before we come to the station, which rests on Lias. Higher up the slope of the hill is found a bed of sand which rests on the Lias, and extends up to the gas-works, where the gravel begins.

We now come to *Rugby* itself, which is on an arm of the plateau at first described. It illustrates very well the singular varieties in the distribution of the sand and gravel. Along the Hillmorton road is gravel, varying in depth from 7 to 13 feet, generally mixed with sand. The School-close is of the same nature; so also is the eastern side of the town down to the George Hotel, where, however, the gravel is thin, and water is obtained from a well 60 feet deep, reaching the rock. In the slope towards the station the gravel becomes thinner. Towards the west of the town we find sand. Billington's is on sand 23 feet thick, St. Matthew's church on sand 20 feet thick; by the side of the road to Newbold the hill is capped with deep sands, the lower part of which is saturated with water. Generally on the south of the Bilton road there is sand; but at several houses on the north there are gravel and clay. There are many curious varieties in the town within a few yards of one another.

Continuing on the edge of the plateau we meet with a *sand-pit* on the way to Newbold (fig. 1). Much of the sand is now removed. There used to be exposed a face of sand of precisely the same character as that at Hillmorton—sugary, dirty, stratified partially, containing few (if any) pebbles, and marked with a few black seams. It was covered with a foot or two of the usual flinty drift. Lower down the slope

it was thinner, and reposed on undisturbed Lias clay. There appears, however, to have been somewhere here a patch of re-formed clay and scratched stones, as my pupils J. B. Alexander and C. S. Taylor and I frequently found stones, apparently glaciated, in this pit, but could never find them *in situ*. There used to be the appearance of the sand graduating into the ordinary drift.

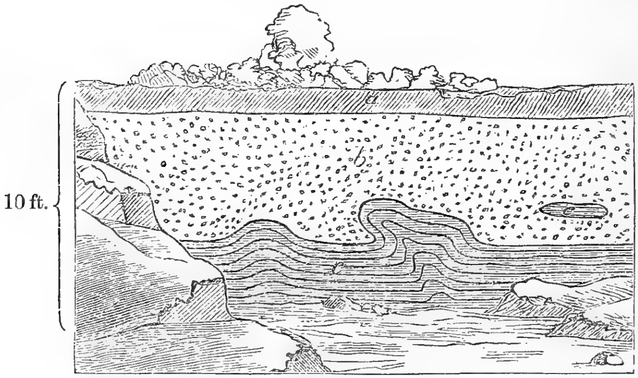
Fig. 1.—*Section in Rugby Pit.*



a. Drift, 2 feet. *b*. Sand, 4 feet. *c*. Brown clay with chalk pebbles.

Very near this is the *New-Bilton Pit*. Here the gravel is from 6 to 10 feet in thickness, deepening towards the hill. The gravel is in some places very rudely and imperfectly stratified. The rounded quartzose pebbles lie, in one section at least, but not universally, with their long axes vertical. The surface soil is easily separable from the drift. The remarkable feature at New Bilton is the inequality of the level of the clay. It is Lias clay, and contains pebbles only just imbedded in its surface; but it is extraordinarily uneven, some ridges rising 5 or 6 feet in height and overhanging their bases, as in the accompanying sketch (fig. 2). The gravel lies in basins and in

Fig. 2.—*Section at New-Bilton Pit.*



a. Surface soil. *b*. Flints and sandy drift. *c*. Lias clay.

furrows in the clay. Occasionally detached portions of the clay, or

what seem to be detached, are seen in the gravel; but I have never been certain of a single case of detachment. Stones are found imbedded in the upper and under surfaces of the clay, notably the latter; I have found no striated stones here. The drift is of the usual character—quartzose pebbles and grits, and flints, in about equal quantities, and sand, which lies sometimes in patches. Some of the stones here are large, one or two feet in circumference.

Continuing to skirt the plateau we come next to that arm of the hill which runs *between the Lawford and Bilton roads.* By the side of the road from Old Bilton to New Bilton is an excavation, in the upper part of which sand is worked, and in the lower clay. The sand caps the hill, and is of the usual character; it is overlain by a remarkable deposit about 5 feet thick where it is now exposed, consisting of marly clay, with pebbles very evenly interspersed through its whole thickness. The most frequent are chalk; and these are generally well striated. The clay is in some cases sufficiently mingled with sand to allow of the percolation of water; and in consequence the chalk is here in a state of powder. There is a block of syenite of considerable size lying on the surface there, and a still larger block, weighing several hundred pounds, of grit, smoothed and striated longitudinally.

The clay with chalk pebbles is very partial on this hill, as far as I know; but the sand continues along the brow of the hill to Rugby.

The *Dunchurch-Road Pit,* higher up the same side valley, and on the same side of it, offers a very instructive section. In March 1869 there was exposed a face of undisturbed Lower Lias clay, containing a few ammonites, &c.; on it rested a stiff brown clay containing many stones, but principally blocks of chalk. I obtained grit (sometimes in large blocks; one was 2 feet long and 1 foot 9 inches broad and high), Oolitic blocks, Lias, many flints, and quartzite pebbles. The chalk is found in pieces of all weights, from 1 cwt. down to dust, the particles of which can only be detected by a microscope. All the larger pebbles are grooved.

The sand is slightly stratified, sugary, and contains grains of chalk universally. In some places crumbling pieces of chalk can still be seen. Mr. Pike reports that $12\frac{1}{2}$ per cent of an average specimen consisted of carbonate of lime and sesquioxide of iron. Above the sand is the usual flinty and quartzose drift, here thin, but higher up the hill successively 6, 10, and 13 feet thick. The drift is entirely wanting a little lower down the slope. The surface of the Boulder-clay here is very uneven; of the Lias clay generally even.

The next arm of the same plateau is that on which Bilton stands. This closely resembles the rest. At the vicarage at Bilton is 2 or 3 feet of gravel and then 23 feet of sand, this being on the slope of the hill; at the top is 13 feet of gravel over clay. Near the Blue Boar, at Causton, and elsewhere in the neighbourhood, we meet with from 5 to 15 feet of gravel, resting on clay with pebbles and sand, and finally on Lias clay. Towards Frankton and Church Lawford

the gravels are considerably thinner. The surface of the clay all over this plateau is said to be extremely uneven, like the waves of a sea.

Sketch of the Surface-deposits on the surrounding High Lands.

I will now take a less detailed survey of the high lands that surround this Rugby plateau, and are separated from it by the valley of Rainsbrook on the south, and by the Avon and its tributaries on the north and east.

Barby hill, to the south of Rugby, is capped with marlstone. There are no sandbeds or deposits of clay with pebbles, that I can find; the wells are fed by surface-drains alone.

At *Kilsby*, however, there is the same clay, with chalk pebbles, that has been already described, and large beds of sand. This is high ground, the level of the rails at the entrance to the tunnel being about 370 feet above the sea. The clay is very stiff, 30 feet thick, and rests on sand. One of the sand-beds at Kilsby is well known from the trouble it gave when the tunnel was being made. About 200 yards from the south end of the tunnel, clay 40 feet thick rests on sand, which is saturated with water, and extends to great distances on each side of the tunnel. It was with the greatest difficulty that the tunnel was constructed through and under it; for the water seemed to be inexhaustible.

At *Crick* the gravel rests on Lias, and the same at *Yelvertoft*.

At *Shawell* is a well 70 or 80 feet deep, which passed in succession through gravel, clay with stones and chalk, and at the bottom reached a bed of sand in which water was found abundantly.

At *Swinford* the gravel is about 10 feet thick, and rests on compacted and cemented gravel.

At *Catthorpe* we find the same gravel, clay with chalk, and sand that we have already met with so often.

At *Clifton* the wells vary from 15 to 40 feet; at Mr. Newall's house, on the brow of the hill looking towards Rugby, a well and boring were made which showed 12 feet of gravel, and 80 feet of clay with pebbles of chalk, sand, and finally Lias clay. The railway-cutting is here sufficiently deep just to enter the clay with chalk-pebbles. They are best seen in the drains on each side of the line. The pebbles are well striated. Pebbles of Oolite and Carboniferous limestone and grit are found in the sand here.

At *Newton* the gravel is thin, resting on clay with pebbles; at 40 feet the sand is reached.

At *Brownsover* the sand resembles that at Hillmorton, and is 40 feet deep. Nearer the mill, on the slope of the hill, the well-sinker reports that he made a boring, preliminary to the building of a house there, in which he bored 60 feet through clay with pebbles, but that he reached no sand, and obtained no water.

At *Churchover* 6 feet of gravel rests on 36 feet of similar clay with pebbles.

At Voile's farm, near Coton House, a boring of 150 feet passed through a few feet of gravel and Lias clay to the limestone rock.

At *Lutterworth* the sand and coarse gravel is 40 feet thick.

At *Harborough Magna* the sand and gravel are 70 feet thick; and about a mile from the village one well was sunk 90 feet, through gravel, clay with pebbles, and, finally, sand.

In the railway-cutting between Brownsover and Newbold, on the Rugby side of the canal, is sand mixed with loam containing flint, syenite, and various kinds of quartzite. Beyond the canal are striated stones of various kinds, chalk and syenite in similar sand, which is there seen to rest on rudely stratified clay with chalk pebbles, below which are other deposits of sand. Near the canal here is a patch of re-formed Lias clay, with abundant blocks of striated Lias limestone, but no chalk.

At *Easenhall* the gravel is deep and very wet.

At *Newnham* gravel is almost wanting.

General Summary of the Surface Deposits.

Deposits on the high Lands.

It appears, then, that on the Rugby plateau, and on the similar high lands in the neighbourhood, the Lias is generally, but not universally, capped with three kinds of superficial deposits. These are—

1. The flinty and quartzose drift.
2. Sugary sand with grains of chalk.
3. Clay with pebbles, principally of chalk, distinctly striated.

Of these 2 and 3 are generally found together, and either may lie on the other; 1 lies over both, and is never found below either; 2 and 3 are never found in any thickness except where lying on the slopes of the hills, and they follow the steep slopes of the valleys with great pertinacity; 1 is found principally on the high levels, thins out everywhere down the slopes, and never reaches the bottom of the valleys; 3 is similarly entirely wanting in the valleys, as far as at present ascertained; 2, or a modification of it, is found in one valley.

Deposits in the Valleys.

The valleys in this neighbourhood are of various widths, sometimes widening out into broad plains, at others very narrow with steep slopes. There are two systems of valleys divided by the Rugby plateau—the valley of the upper Avon on the north, and that of the Leam on the south. The bottom of the valley is generally a narrow strip of alluvial soil, bordered by sand in some places, by drift in others, while, again, in other places all the surface-deposits are wanting. No wells or other excavations exist in the valleys; and I determined to make some borings with a view to ascertain the nature of the underlying strata. It might have been presumed that the valleys were excavated in the Lias clay, and that therefore just below a few feet of alluvial soil we should find the Lias. The result is startlingly different from what I expected. I have examined only the valley of Lowmorton in any detail. This is a lateral valley of the Avon.

The valley near Hillmorton church is very singular in its character. All round the church, and extending up and down the valley for some distance, is a peat-bed, which is exposed in some of the deep ditches. Underneath it is sand, so impregnated with water as to be called a quicksand. It appears that not long ago all this was a marsh; for Dr. Bucknill, of Hillmorton Hall, informs me that a sum of money was left to the parish to keep up a floating causeway over the marsh to the church, which stands on firm ground in the middle of the valley. Sand overlies the peat at the bridge over the canal near the church, just opposite the mouth of the narrow valley with the sand-pits in which the village lies. The London and North-western railway crosses a portion of the marsh; and immense quantities of ballast were thrown in to make a firm foundation; finally, I am informed, faggots were used as a foundation for the embankment. Similar difficulties were met with in constructing the canal. The excavations at the locks drained the sand, and the fall of the neighbouring houses seemed imminent. These houses are built in some cases on large slabs of concrete resting on the wet sand.

I caused a boring to be made here near the New Inn. It gave:—peat 3 feet, clay 1 foot, sand 25 feet; and it was impossible to proceed further. The sand was mixed with fine clay, and contained a good deal of lime, so that when dried it soon became perfectly hard. The microscope showed grains of chalk and of rolled quartzose sand. The bottom of this boring was 280 feet above the sea.

The next boring was made in a meadow belonging to Dr. Bucknill, called the Moors. It gave 2 feet peat, 13 feet wet sand, 3 feet gravel, and then sand, more and more clayey and stiff, passing from yellowish to grey until it became too stiff for boring at 53 feet. All this sand contained fine clay and particles of chalk, effervesced slowly but continuously with acids, and was entirely unlike Lias clay. A very few small stones were met with, but not preserved.

The next boring was on the left-hand side of the road from Rugby to Clifton, on the right bank, close to the stream. It passed through 6 feet of alluvial soil and clay, then a mass of vegetable matter, being the decayed vegetation of the old river-bed, and then reached sand similar to that higher up the stream at Hillmorton. Several stones, flints, grits, and quartzite were met with in this boring. The lower part yielded a considerable quantity of chalk lumps in the clay. This boring was persevered in till 57 feet were passed through, and then rock was reached, and some fragments of limestone brought up. The bottom of this boring was 227 feet above the level of the sea.

The last boring was lower down the stream, close to the planks on the left bank of the river. It passed through fine yellow clay for 7 feet, then stones and sand for an inch or two, and then undisturbed Lias clay, totally unlike the clays previously reached. The boring was continued for 20 feet through this, and then stopped. The surface of the Lias clay here is 274 feet above the sea.

The relations of these borings will be understood by reference to

the diagram (fig. 3). The surface of the clay is quite different from the present surface of the country.

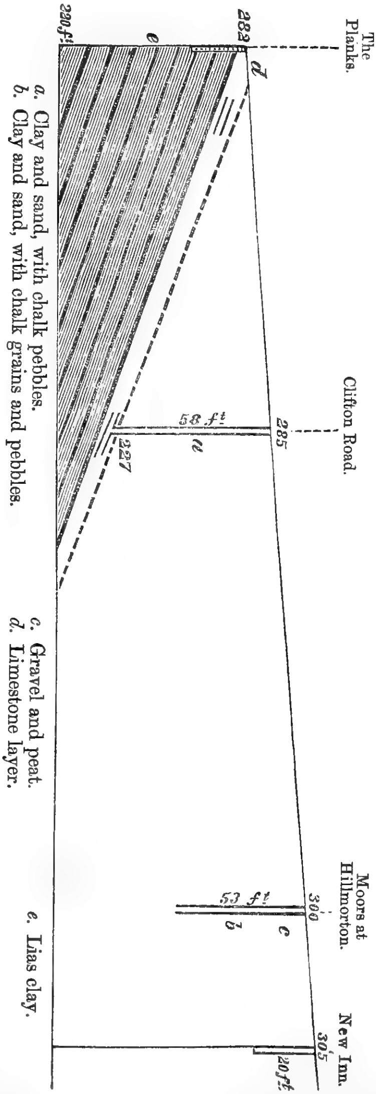


Fig. 3.—*Longitudinal Section of the Valley of Hillmorton.*—Distance $2\frac{1}{2}$ miles.

The most remarkable spot in this river-valley is the pit near Lawford, from which Dr. Buckland extracted so many valuable mammalian remains. This is now a pit containing water, nearly filled, however, with sand washed into it by a little stream.

The other valley of Rainsbrook and the Leam is of the same general nature. Alluvial meadows, with a meandering stream, occupy the centre; the broad base of the valley, however, is studded with numerous slight elevations. No borings have been made there, and there is absolutely no knowledge of the subjacent deposits. At Willoughby some mammalian remains were discovered, about which Mr. Goldney, of Willoughby, was good enough to furnish me with the annexed extracts from Deacon's 'History of Willoughby' (London, 1828). "The antediluvian remains which have been discovered at this place are the teeth and tusks of the Mammoth or Asiatic Elephant [p. 43]. The teeth first discovered in this village were dug out of gravel, about 12 feet from the surface of the earth, in a field near the Public School, about forty years ago [sc. 1788]. There was discovered at the same time a tusk weighing about 30 lbs., 5 feet long, and curved to the amount of three quarters of a circle. Another discovery of a tooth and tusk was made about two years ago, but the workmen broke the tusk."

Lower down these valleys, at Leamington, when excavations were being made in the Jephson Gardens, bones of Elephant and Rhinoceros were found.

It remains now only to speak of the alluvial soil in these valleys and its contents. It does not appear to be anywhere very thick; perhaps 7 or 8 feet is the outside; and it therefore merely fills up slight depressions in the valleys previously existing. The present streams go on adding to the alluvial soil by the frequent floods, and must be considered adequate to have produced the whole of it.

The discovery of bones in this alluvium a few years ago caused considerable interest. This discovery was due to the industry and acuteness of Mr. E. Cleminshaw, then a pupil in the School. He made the discovery entirely his own by finding several places where such bones are to be met with. The most interesting of these are in the bed and banks of the stream near Newton, in the Avon a little below Newbold, and close by the little bridge below the Little-Lawford Mill. These bones have not been specifically determined; and I cannot pronounce on them. A large collection of them is in the Arnold Library at Rugby. Three or four flints were found with them, which have been pronounced by fairly competent judges to be probably flint weapons. But I found in one of these localities, associated with the same bones, a piece of a wine-bottle, some pottery, not ancient, and the bowl of a tobacco-pipe; I am therefore sceptical.

This concludes this short notice on the superficial deposits near Rugby; and I am not without hope it may be found useful to those who are engaged upon the problem of determining the history of the processes which the surface of the midland counties has undergone in the latest geological ages.

---

3. *On the* Superficial Deposits *of* Portions *of the* Avon *and* Severn Valleys *and adjoining Districts.* By T. G. B. Lloyd, Esq., C.E., F.G.S.

Introduction.

In the following paper I propose to describe first of all the facts which I have collected together upon the subject, and secondly to show what probable inferences may be drawn from them, in explanation of the relative antiquity of these river-valleys and their superficial deposits.

Part I. The Superficial Deposits of the Valley of the Avon.

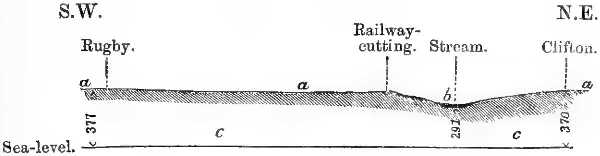
Literature of the Subject.—Sir W. Jardine's 'Memoirs of H. E. Strickland' contain several papers on the Geology of Worcestershire and Warwickshire, in which are found very clear and accurate descriptions of many of the phenomena of the drifted deposits of the Avon valley and surrounding country. An account is given of the late Professor Strickland's discovery of land- and freshwater shells, associated with mammalian remains, in the gravel-beds of

the Avon Valley, near Cropthorne in Worcestershire, which are referred to by Sir R. I. Murchison in his 'Silurian System.' My own investigations are merely an extension of those commenced by Strickland, to whose writings I am much indebted for valuable information, and many suggestions.

In July 1868, a paper was read by Mr. E. Cleminshaw, at a meeting of the Nat. Hist. Society of Rugby School, on the river-gravels of the Avon in the neighbourhood of Rugby; and this was followed in the published report by a note written by Mr. Jas. M. Wilson, F.G.S., which I recommend as worthy of the attention of all who are studying Postpliocene geology. I must also refer to a short paper by the Rev. P. B. Brodie, F.G.S., called "Remarks on the Drift in a part of Warwickshire" (Quart. Journ. Geol. Soc. vol. xxiii.). In Sir R. I. Murchison's chapters on Drift, in the 'Silurian System,' the subject of the *northern* drift is extensively worked out.

General description of the River and Valley of the Avon.—The

Fig. 1.—*Section across the Valley of a Tributary of the Avon.*
Distance 2 miles.



a, a, a. Drift of Upper series. *b.* Alluvium.
c, c. Lower Lias clay and limestone.

river Avon rises near Naseby, in Northamptonshire, whence, taking a south-westerly course by Rugby, Warwick, and Stratford-on-Avon, it flows past the town of Evesham through a narrow bend of the valley, below which it enters a broad alluvial plain, and, following a tortuous course by Fladbury, Cropthorne, Pershore, and Defford, finally enters the Severn at Tewkesbury, having accomplished a distance from Rugby, as measured along the valley, of about sixty-four miles. Its principal affluents are the Swift, the Leam, the Arrow, and the Bow. The basement rocks, which belong to the district of the valley between Rugby and Tewkesbury, occur in the following order:—Lower Lias limestone and clay from Rugby to King's Newnham; New Red marl and "waterstones" from King's Newnham to Cloud Bridge; Permian conglomerate from the latter place to within a few miles of Warwick, where the Keuper series reappears; between Stratford-on-Avon and Tewkesbury the Lower Lias clay predominates, the Keuper marls occupying only a narrow area of about six miles in width between Stratford and Evesham, and occurring again on a line of fault near Fladbury. Bredon Hill is an outlier of Blue Lias clay and Inferior Oolite.

Description of Transverse Sections.—In a section taken across the valley of a tributary stream between Rugby and Clifton (fig. 1), *a, a, a* represent beds of Boulder-clay, quartzose flinty gravel

and sand, capping the higher ground at Rugby and Clifton, and descending into the valley, where they increase in thickness; *c, c,* the supposed position of the Lower Lias clay on which the drift lies.

In a section taken across the valley of the Avon, from the summit of the hill on which the town of Rugby stands to the Brownsover intrenchments, excavations made on different parts of the hill show that the Boulder-clay, with its associated beds of gravel and sand probably extends some distance down its flanks. A boring made on the line of section near the river came upon the Lias at a depth of six feet from the surface. On the hill towards Brownsover the existence of the Boulder-clay and other drift could only be inferred. The modern alluvium on each side of the river is the only freshwater deposit apparently existing thereabouts.

Fig. 2 represents a typical section across the Avon valley, from the summit of Bredon Hill to the top of Cracombe Hill, which is taken along such parts of the valley as illustrate in the best manner the relative distribution of the different classes of the superficial deposits.

Fig. 2.—*Typical Section across the main Valley of the Avon, near Cropthorne, Worcestershire.*—Distance $5\frac{1}{4}$ miles.

b, b, b. Isolated beds of the Lower series; near Beckford, local drift with marine shells and mammalian remains. *c, c.* Freshwater gravel and brick-earth; near the Avon, with shells and mammalian remains. *d.* Modern alluvium. *e.* Inferior Oolite, Upper Lias shale and marlstone. *f.* Lower Lias shale.

Provisional Classification of the superficial Deposits of the Valley of the Avon and adjoining districts.*

Upper Series, ranging from 430 feet to 300 feet above the sea:—

* The letters refer to the localities in the Table (p. 216); and the numbers denote the order of the succession of the beds from the surface of the ground downwards.

A (1). Quartzose flinty gravel and sand (usually stratified). "General Flinty Drift" of Strickland.

B (2). Boulder-clay. A stiff, compact mass of sandy unstratified clay or earth, varying from a slaty blue to a purple colour, full of grooved and striated boulders of blue Lias limestone, white Chalk, and white Lias limestone, smoothed and polished pebbles of quartzite, showing fine striæ on their surfaces, scratched subangular flints, and subangular blocks of syenite. In places there are thin seams and lenticular masses of quartzose sand imbedded in it.

B (2). A light-red, sandy, unstratified clay, compact and hard, containing quartzose pebbles and a few boulders, which occasionally exhibit traces of glacial action. In places the colour of the clay changes to a dark brown or chocolate tint.

C (3). Laminated clay of brown and green colours.

D (4). Laminated sand of a light red colour.

E (5). Clean, quartzose flinty gravel and sharp sand, containing gryphites much water-worn, and other derivative fossils (unstratified).

F. "General quartzose Drift" of Strickland, or "Northern Drift" of Sir R. I. Murchison. It consists, as far as I have been able to ascertain, of a red compact loam, and light-red quartzose sand, which contain quartzite pebbles and fragments of other rocks (mainly unstratified), viz. of white quartz, felstone, flints, &c.

Lower Series, ranging from 300 feet to 50 feet above the level of the sea:—

G. "General Flinty Drift" of Strickland. Beds of quartzose flinty gravel, generally unstratified, but occasionally showing a stratified arrangement in the lowest and uppermost beds.

H. "Local Drift" of Strickland, principally composed of detritus from the Oolitic rocks in its immediate vicinity, with a small proportion of quartzose pebbles, sand, and flints. The beds are stratified, and contain in places marine shells and mammalian remains.

Freshwater Deposits, ranging from about 290 feet near Rugby to somewhat near 30 feet above the level of the sea:—

Quartzose flinty gravel and sand, with occasional seams of clay. Light-red loam or brick-earth. Peat. Modern alluvium.	Land and freshwater shells and mammalian remains.

The above classification may appear to many needlessly detailed; but I have adopted it after a good deal of consideration, as being one which, I think, is best adapted for excluding all theoretical assumptions regarding the relative connexion and sequence in point of time of the different classes into which I have divided the drifted deposits. In some cases the apparent absence of certain beds and the non-occurrence of marine shells and mammalian remains rest entirely on negative evidence, which future investigations may modify.

The late Professor Strickland divided what he called the marine

drifts of Worcestershire and Warwickshire into three classes, viz. "(1) Erratic gravel without chalk-flints, (2) Erratic gravel with chalk-flints, (3) Local or non-erratic gravel;" from which it appears that he was not aware of the existence of the Boulder-clay in those counties, although he mentions the occurrence of a stiff clay, containing fragments of chalk, near Princethorpe, in Warwickshire.

Description of the Drifts of the Upper Series.—Referring to the accurate descriptions of the several classes of drift and their geographical distribution, contained in the papers of Strickland previously mentioned, I shall confine myself to some observations bearing on the extension of the subject which I have had the opportunity of making.

A (1). This deposit of quartzose flinty gravel and sand is found overlying the Boulder-clay in the neighbourhood of Rugby; in some places it rests immediately upon the basement rock, as at Kenilworth, where it shows signs of stratification, the sand being laminated in the middle bed. A small rounded boulder of grey-coloured porphyritic granite was observed lying in the upper gravel-pit adjoining.

B (2). The area covered by the Lower Lias clay defines pretty accurately the boundary of the purple-coloured Boulder-clay in the north-east part of Warwickshire. The deposit is irregularly distributed over the surface of the high ground, whence it descends into portions of the valleys, attaining a considerable thickness in both situations.

B (2), F. After leaving the district of the Lias, and passing downwards to the region of the New Red Marls, we find a change in the composition and colour of the unstratified beds. Although I have separated them into two classes B (2) and F,—their characteristic features are so much alike, that I believe they both belong to the "General Quartzose Drift" of Strickland, or "Northern Drift" of Sir R. I. Murchison. The composition of the beds in the district in question has been described in general terms by Strickland. With regard to the occurrence of flints in them, my observations have led me to conclude that these are distributed through the beds in a persistent manner, although the relative proportion of them to the other components is small. Seams of carbonaceous matter and lumps of drifted coal are not unfrequently met with. In a sand-pit on the north-west side of Cracombe Hill I observed a peculiarly contorted arrangement of the beds. Narrow seams of finely laminated sand of a red colour were seen interbedded between layers of fine sandy gravel. On the right-hand side of the section appeared a thin seam of light-coloured marl following a curved direction. The longer axes of the pebbles and the sand-seams were inclined at an angle of about 70° N.W. At Sheriff's Lench and in the quartzose flinty gravel at Bredon I have observed somewhat similar phenomena. The liver-coloured and greyish pebbles of quartzite, so abundant in these beds, are commonly found broken in half, having their fractured edges slightly rounded; their surfaces exhibit small hollows of a lightish colour, due probably to disintegration. The pebbles

in the Bunter-conglomerate beds in the neighbourhood of Bromsgrove, present in many cases the same appearances; and some of them are found with cracks across them, which yield to the pressure of the hand.

C (3) has only been observed hitherto at Snitterfield, Welcombe Hill, and in a brickfield near the New Inn, Ridgway, accompanying the beds B (2) and F. It varies from about 7 feet to 4 feet in thickness.

D (4). This bed appears to be the one which is most persistent in its occurrence of any in the upper series. It has been traced from the neighbourhood of Rugby, where it attains to a minimum thickness of about 50 feet near Hillmorton, to near Princethorpe, where it occurs both under the Boulder-clay and between it. It is met with again in the neighbourhood of Warwick and Leamington, continuing down as far as the Lenches, beyond which there is no certain evidence of its occurrence, although it probably underlies the red loam on Cracombe and Charlton hills. The exact thickness of the bed has not yet been ascertained where it occurs in the neighbourhood of Rugby; but in the district of the New Red marl it averages about 10 feet in thickness. In some of the localities it contains quartzose pebbles and flints.

E (5). This deposit bears much resemblance to the freshwater gravel hereafter to be described. It appears to be a well-washed bed of gravel and sand, containing pebbles of white quartz, a few flints, and numerous water-worn specimens of *Gryphæa incurva* and Belemnites. I also obtained from it a fragment of coral and what appeared to be a fragment of Encrinite limestone. It is doubtful whether it exhibits any signs of stratification or not. The only localities in which I have met with it are at Snitterfield, near Warwick, near the Brickyard, Leamington, and Welcombe Hill, near Stratford-on-Avon. It is said to occur near the "New Inn" on the Ridgway.

In order to make clearer the order of superposition of the deposits above described, I subjoin two typical sections—the one taken from the beds occurring in the Lias district, and the other from the area of the New Red marls.

Section A.

		ft.
A. (1).	Average thickness.................	7
B. (2).	On the high ground..............	9
,,	When occurring in a valley ...	30 and upwards.
D. (4).	Total thickness unknown	50 and upwards.

Basement rock—Lower Lias clay and limestone.

Section B.

	ft.
B (2) and F. Average thickness about	10
C. (3) Average thickness about	3
D. (4) Average thickness about	10
E. (5) Average thickness uncertain.	

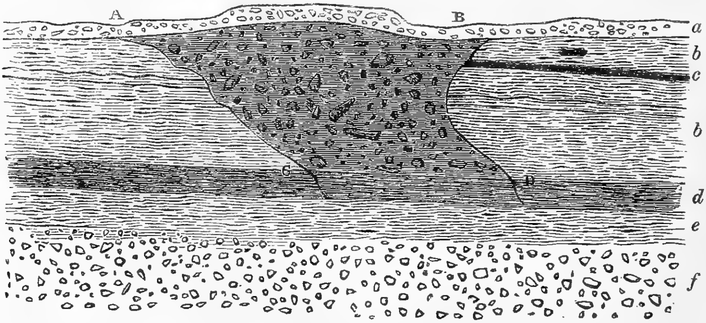
Basement rock principally New Red marl *.

* Some of the localities, although occurring on the Lias, are in the vicinity of the New Red marls.

Before concluding the description of the beds of the Upper Series, it may be well to call attention to a singular arrangement of drift which occurs in a brick-pit on Black Hill, Snitterfield, near Warwick (fig. 3).

A somewhat wedge-shaped mass of compact "clunchy" clay of red and greenish colours was observed on the face of the pit to break the continuity of a bed of light-red loam, and to rest, as far as one was able to judge, upon the laminated clay below. Its dimensions, as measured on the face of the section, were 66 feet from A to B, 30 feet from C to D, vertical depth 19 feet. The total size of the mass is not known, nor was I able to trace its superficial area. It appeared to contain sand mixed up with clay and quartzose pebbles. The locality is on the most elevated ground thereabouts. I could not detect any dislocation of the beds of red loam along the lines A to C and B to D. I may mention here that a fragment of bone, now in the possession of Mr. Kirshaw, F.G.S., of Warwick, was said by the foreman to have been found in the gravel-bed below.

Fig. 3.—*Section in Brick-yard at Black Hill, Snitterfield.*



a. Surface-soil. *b.* Light-red loam and sand. *c.* Carbonaceous seam. *d.* Finely laminated green and reddish-brown clay. *e.* Finely laminated light red quartzose sand. *f.* Quartzose sand and gravel, with *Gryphææ*, Belemnites, Encrinital limestone, &c.

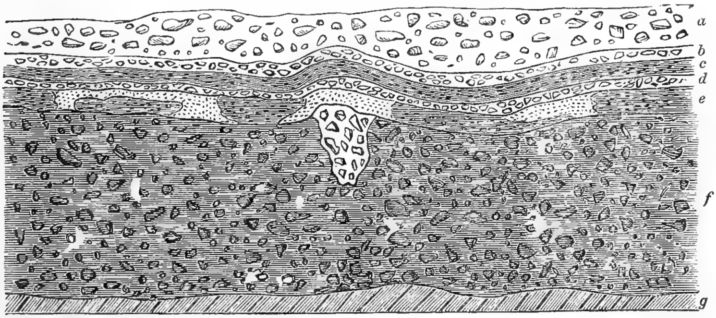
Lower Series.

G. Starting from the discovery of a bed of unstratified quartzose flinty drift at Bredon, near Tewkesbury, which was described by Strickland under the head of "Marine Erratic Gravel with Flints" (Trans. Geol. Soc. N. S. vi. p. 554), I have succeeded in tracing the existence of beds of a similar character in various localities, from Berry's Coppice, near Donnington, to within a short distance of Tewkesbury. As will be seen from the general Table of Localities, they occupy elevations from 180 feet to 67 feet above the river Avon. As a general rule, decreasing in altitude seaward, on the south-east side of the Avon, between Evesham and Bredon, they range along the upper edge of an escarpment of Lias which lies at the base of what I have termed the main valley; at the bottom of

the escarpment the outer edges of the freshwater beds are seen to rest. On the north-west side of the Avon isolated patches of the same class of deposits are found on the upper side of the valley of the Arrow, near Donnington, on the summits of Green Hill, Evesham, Mount Pleasant, Pershore, and on the commons of Shut-hanger and Shoebarrow, near Tewkesbury. They may be said to consist, for the most part, of red loam and sand, containing pebbles of white quartz, quartzite, and felstone, associated with a considerable percentage of black flints, which seem, in many cases, but slightly water-worn, besides numerous angular flake-like fragments of a whitish siliceous substance, which appear to be composed either of flint or chert. At Bengeworth Hill and Green Hill, near Evesham, the beds average 5 feet in thickness; at the former locality the surface of Blue Lias clay on which they rest is much eroded; their maximum thickness, wherever I have had an opportunity of measuring them, was about 15 feet.

At Berry's Coppice, near Donnington, and on Cropthorne Heath, an unstratified bed of ferruginous gravel contains, in its upper part, small pockets and accretions of a light-coloured siliceous sand, mixed with pebbles (fig. 4). In one part of the pit on Cropthorne Heath I observed a pocket of ferruginous gravel without any intermixture of the whitish sand, in which the pebbles were arranged principally with their longer axes variously inclined, accommodating themselves, as it were, to the truncated conical form of the pocket. In the section a singular ridge and furrow-like outline of the stratified

Fig. 4.—*South Face of Gravel-pit on Cropthorne Heath.*



a. Light grey vegetable soil with a few pebbles. *b.* Fine gravel. *c.* Red sand. *d.* Fine gravel. *e.* Red and white sand. *f.* Coarse ferruginous gravel and loamy sand. *g.* Blue Lias clay.

portion of the beds is seen, the red sand of which is of a lighter colour than that of the bed below. The pebbles appear to be alike in character throughout the deposit. At Berry's Coppice the highly inclined position of the pebbles in the ferruginous gravel is seen extending throughout a considerable portion of the section. In the same locality stratified sand and gravel was seen near the bottom of the pit. In the seams composed partly of whitish and partly of red

sand I found a fragment of a shell which Mr. Etheridge considered to be a portion of a *Cyprina islandica*, remarking at the time that it was a very difficult piece to determine. At Brick Hill I have observed accretions of whitish sand in a bed of light-red loam; and on Mount Pleasant the same kind of sand has been met with. It may be remarked here that the deposit on Cropthorne Heath, described above, is partially surrounded by beds of freshwater origin, between which there is a minimum difference of height of 30 feet.

H. About three years ago, during the construction of the Evesham and Ashchurch railway, a large excavation was made for ballast at the base of Bredon Hill, near Beckford, where the following section was exposed, for an account of which I am indebted to Mr. W. C. Lucy, F.G.S., of Gloucester.

No. 1.

	ft.	in.
(1) Soil	3	0
(2) Gravel	9	0
(3) Seam of clay	0	2
(4) Gravel	0	3
(5) Discontinuous bed of clay	0	2
(6) Gravel	0	3
	12	10

Basement bed of Lower Lias clay reached at 17 feet below the surface.

On visiting the locality I found that the former excavations had been filled in; but near the north-east end of the old workings the following section was exposed in a sand-pit.

No. 2.

	ft.	in.
Surface of ground.		
(1) Dark-brown earth without pebbles	3	3
(2) Bed of coarse fragments of Oolitic limestone ...	2	9
(3) Beds of small fragments of Oolitic rock, alternating with thin seams of light-coloured quartzose sand	7	0
Bottom of pit.		
	13	0

The beds nos. 2 and 3 contained Oolitic fossils, quartzose pebbles, and flints.

In a sand-pit at Bredon's Norton I counted as many as thirteen alternations of gravel, sand, and clay in a vertical depth of about $4\frac{1}{2}$ feet.

Judging from the depth of the basement clay in Section No. 1, it would appear that the total thickness of the deposit in the sand-pit at Beckford is about 20 feet. From the contour of the surface of the ground in the neighbourhood, it seems likely that the beds in question form mound-shaped accumulations, which slope upwards towards the summit of Bredon Hill, and extend round a considerable portion of its base.

In Mr. W. Boyd Dawkins's list of Postglacial Mammals (Quart.

Journ. Geol. Soc. vol. xxv. p. 195) the following mammalia are noted under the locality "Beckford."

Cervus tarandus.	Sus scrofa.
Bos primigenius.	Rhinoceros tichorhinus.
Bison priscus.	Elephas primigenius.

The President of the Cotteswold Club, Sir W. V. Guise, Bart., F.G.S., in his address for 1865, stated that, when at Beckford, in company with the Rev. W. S. Symonds, he found a fragment of a shell which Mr. Gwyn Jeffreys pronounced to be a portion of a *Lucina borealis.* I have also seen it stated that Miss Holland, of Dumbleton, found a *Rissoa* at the same place.

Before concluding the description of the Lower Series I may perhaps be permitted to call attention to the occurrence of a stratified deposit occurring on the eastern side of Cropthorne Hill, which has not yielded hitherto any positive evidence to show whether it is of marine or freshwater origin. A section in a sand-pit gives:—

	(Surface of ground 110 feet above the sea, and 60 feet above the Avon.)	ft.	in.
(1)	Vegetable soil	1	0
(2)	Irregular bed of dark red loam, containing large and small pebbles of white quartz and flints	4	0
(3)	Fine red laminated sand	2	0
(4)	Quartzose gravel	0	3
(5)	Fine red sand	3	0
(6)	Quartzose gravel	0	3
(7)	Fine red sand	1	0
(8)	Quartzose gravel	0	2
(9)	Light-red laminated sand	3	0
(10)	Dark red loam	0	6
(11)	Dark red sand	4	0
(12)	Red clayey loam	0	2
(13)	Red sand	2	6
	Bottom of pit.		
		21	10

The sand has been excavated to a depth of about 30 feet from the surface without having reached the basement rock. No traces of mammalian or molluscan remains have hitherto been discovered. The summit of the hill on which the village of Cropthorne stands is covered by a capping of gravel, apparently of a similar character to that occurring on Cropthorne Heath, already described. As far as I am aware, boulders are seldom met with in the gravelly drift of the Upper and Lower Series.

Freshwater Deposits.—Quartzose, flinty gravel, and sand, with occasional seams of clay. (Land and freshwater shells and mammalian remains.)

From some point between the villages of Lawford and Stoneleigh, the exact locality of which is not known, beds of alluvial gravel and sand can be traced, with occasional interruptions, on both sides of the Avon, to within a short distance of the town of Tewkesbury, their heights above the river increasing for the most part as they approach its mouth. On the whole they present a remarkable uniformity of composition, thickness, and arrangement of parts,

though between Stratford-on-Avon and Evesham they appear to contain fewer flints in proportion to the rest of their constituents than the deposits of a similar class occurring higher up and lower down the valley. The width of the beds from above Stoneleigh to Evesham is on an average about $\frac{3}{4}$ mile. Between Evesham and Tewkesbury they attain their maximum superficial development, having a width of about $1\frac{1}{4}$ mile. The average thickness of the beds, taken from measurements in eighteen different localities, is 7 ft., their maximum thickness being 12 ft. The inner margins of the beds form in most cases banks about 3 ft. in height above the surface of the modern alluvium. I have no positive evidence to show whether the gravel-beds pass under the latter; but from accounts which I have received of several borings made down to the basement-rock in different localities, it would appear that no gravel was met with. As Strickland formerly remarked, this description of Drift appears to be made up of the other three kinds, viz. the "quartzose, the "flinty," and the "local" drifts. The bed resting on the basement-rock is in most cases composed of sand, which fills up the furrows occurring in the rock.

By means of levels taken at different points across the valley, near Fladbury and Cropthorne, I have been enabled to group together the isolated patches of gravel occurring thereabouts, as will be seen in the following Table:—

	Approximate heights above the river. feet.
Localities situated on the Right Bank of the River.	
Railway-cutting, Fladbury	30
Gravel-pit in the Rector's Field, Fladbury	25
Gravel-pit near the outer edge of the modern alluvium, Spring Hill	10
Gravel-pit on north side of Farm-house, Spring Hill	20
Gravel-pit on east side of same	21
Gravel-pit near Moore	23
Ballast-pit near Wyre	25
Localities situated on the Left Bank of the River.	
Bank of gravel adjoining the modern alluvium, Fern Hill	14
Gravel-pit in farm-yard, Charlton	29
Ballast-pit, near Charlton	30
Gravel-pit near Cropthorne Ford	21
Gravel-pit in North Charlton Field	25
* Gravel-pit near the "New Inn," Cropthorne	40
* Old Brickyard near Bricklehampton Bank (about)	37
* Gravel-pit on top of river-bank, near Wick	31
* Gravel-pit near Little Comberton	40

Some of the localities (bracketed together) are situated on the same plateau of gravel, whilst others are cut off from it by the valleys of small streams. The beds where the localities marked by asterisks occur do not appear to be connected in an obvious manner with the rest. I may therefore, perhaps, be allowed to describe them more in detail.

Cropthorne Heath, where the drift-gravel containing the light-coloured sand is found, occupies a central position with regard to the

localities in question. On the east lies the gravel-pit near the New Inn, separated from it by a small valley, through which a brook runs; the brick-yard near Bricklehampton Bank faces the river on the west; whilst to the south is seen the shallow valley in which the pits near Little Comberton and Wick are situated. As may be seen from the Table (p. 216), the elevation of the drift in the gravel-pit on Cropthorne Heath is 33 ft. above the mean height of the freshwater beds in the four localities just named.

Section in Gravel-pit near the New Inn, Cropthorne.

	ft.	in.
Surface of Ground.		
Light-coloured earthy clay, with a few pebbles	1	8
Red cohesive clay	1	6
Quartzose flinty gravel, with chalky-looking seams and layers of red and light-grey sand (whitish)	3	0
Quartzose flinty gravel, with layers of red and whitish sand (no chalky seams)	1	10
Light-red sand, obliquely laminated with a seam of gravel 1 inch thick	1	0
Red sandy clay, adhesive when moist	1	0
Light-grey sand (whitish)	1	0
Blue Lias clay.	11	0

A considerable number of large quartzose pebbles were mixed up with the finer gravel. A rounded boulder of Felstone, measuring about 2 ft. 2 in. × 1 ft., was found lying on the surface of the Lias clay.

The gravel-pit near Little Comberton, remarkable for having yielded a very fine tusk of *Hippopotamus major*, now in the Worcester Museum, is situated at a distance of about a mile from the present river. A section in it was as follows:—

		ft.	in.
	Surface of Ground.		
(1)	Light-coloured marly earth, with a few pebbles	2	0
(2)	Fine, quartzose flinty gravel, with seams of light-red sand	4	0
(3)	Light-red sand, with small pebbles (chiefly of flint)	0	3
(4)	Fine, quartzose, flinty gravel, and red sand	1	0
(5)	Whitish-coloured sand	0	6
(6)	Fine, quartzose, flinty gravel, and red sand	2	6
	Blue Lias clay.	10	3

In the bed no. 5 I found numerous specimens of freshwater shells enclosed in streaks of light-red clay. The surface of the basement clay was very uneven. In another part of the same pit, now filled in, the Rev. W. Parker, of Little Comberton, informed me he had found the lowest stratum composed of mud containing freshwater shells and remains of aquatic plants, lying on an uneven surface of blue Lias clay. For a description of the brick-earth and gravel near Bricklehampton Bank, I must refer my readers to the Strickland Memoirs, page 98, and the 'Silurian System,' pages 555, 556).

Boulders are occasionally met with in the freshwater gravels, occurring on the surface of the basement clay. The largest I have seen was found in the ballast-pit near Charlton; it was composed

of Felstone, and measured 4 ft. × 1 ft. 8 in. × 1 ft. 4 in. The derivative fossils are chiefly *Cardiniæ*, gryphites, and corals from the Lias beds, with belemnites &c. from the Oolite. Fragments of silicified wood, such as is found near Coventry, in the Permian Sandstone, are found in the gravel round Warwick.

I am indebted to Mr. R. C. Tomes, F.L.S., for the following remarks on the local distribution of the corals occurring in the gravel:—"In the fluviatile gravel of Leamington (on the river Leam) a species of *Montlivaltia* occurs pretty frequently, which is so plentiful in the upper beds of the Lower Lias at Fenny Compton, about 10 miles distant. Lower down the Avon, at Welford, below Stratford-on-Avon, the gravel contains a small Lias coral, *Montlivaltia rugosa*, found in the corresponding bed in the Lower Lias at Honeybourne, about 5 or 6 miles distant. At Fladbury are found specimens of the Mesozoic *Septastræa Eveshami* and *Haimii* from the adjacent '*Angulatus*-beds' of Chadbury. The specimens of *Septastræa* show but little signs of attrition, whilst a Silurian coral (from Charlton ballast-pit) appears much water-worn. Near Upton Snodsbury I obtained a specimen of *Septastræa* from the beds of gravel, which contain but few flints, in the valley of the Bow, where also mammalian remains and freshwater shells have been discovered."

There are only two localities in the valley of the Avon, between Rugby and Tewkesbury, in which deposits of brickearth have been met with, as far as I am aware, viz. at Bengeworth, near Evesham, and at Bricklehampton Bank, near Cropthorne, before alluded to. In the latter the workings have been abandoned for many years past, and are now entirely covered up. The beds of brickearth and gravel at Bengeworth are exposed in a brick-yard on the north-west side of Knowle Hill, where they rest on a bed of blue Lias clay at a distance of about half a mile from the river. I have been unable to ascertain their superficial extent, in consequence of the absence of any exposure of them, excepting at the locality in question. On the north-east side of the pit a bed of unstratified quartzose flinty gravel belonging to the "Lower Series" appears to be cut off towards the south-west by the brickearth. The height of the surface of the loam above the river is somewhere about 60 ft. The valley thereabouts is narrow and deep. On the north-east the loam has been removed, and the excavation filled up in part. The dip of the lower gravel-bed is 5° N.E. and S.W. (I have omitted the dips in the preceding descriptions, having found, by repeated trials that, when taken over so limited an area as is exposed in a ordinary gravel-pit, they were not to be relied on.) I believe the mammalian remains were found chiefly in the lower gravel-bed, and that the specimens of *Unio ovalis* occurred in the loam. A section taken near the centre of the pit exhibited the following arrangement:—

	ft.	in.
(1) Light-red loam, containing local seams of fine quartzose flinty gravel	20	0
(2) Quartzose flinty gravel and sand	2	6
	22	6

Peat-beds.—A bed of peat about 8 ft. thick, resting on gravel, was cut through some years ago at Chadbury; in it many horns of Red Deer were found.

Modern Alluvium.—This deposit of alluvial silt, containing layers of vegetable matter, mammalian remains, and land and freshwater shells, seems to be continuous from Rugby to Tewkesbury, increasing in thickness as we descend the river, from about 6 ft. to about 15 ft. In the neighbourhood of Rugby, near Little Lawford, a well-known discovery of mammalian remains and shells was made in the year 1815, of which a short account is given in Dr. Buckland's 'Reliquiæ Diluvianæ.' I believe that the Rev. Andrew Bloxam, then residing at Rugby, was the first person to call Dr. Buckland's attention to the discovery. In a letter to me, in reply to a query about the meaning of the term "drift," as applied by him to the deposit in which the remains were found, Mr. Bloxam says, "The drift in your plan, as far as I can remember, was alluvial loamy soil, at the bottom of which, just above the clay (Lias?), was a layer of a few inches thick of a black peaty kind of deposit, in which the bones were deposited, some of which, however, had sunk into the clay beneath." Dr. Buckland remarks, in his work, that the bones appeared not in the least degree mineralized, and had lost scarcely any thing of their animal matter and weight.

As a general rule, the mammalian remains have been found, according to all accounts, either resting immediately on the surface of the basement clay or else in the lowermost beds of the freshwater gravels. The land and freshwater shells have been pretty much confined to the lower beds in the few localities where they have hitherto been found; with the exception of the case recorded by Sir R. Murchison, near Bricklehampton Bank, the bones &c. usually have occurred singly, and the shells were well preserved, with their valves often in contact. No stone implements, as yet authenticated, have, I believe, been found in the superficial deposits of the Avon valley.

List of Mammalia from the Freshwater Deposits of the Avon, compiled from Mr. Dawkins's Table.

Canis lupus.	Bison priscus.	Rhinoceros tichorhinus.
Hyæna spelæa.	Hippopotamus major.	Elephas antiquus.
Cervus tarandus.	Sus scrofa.	E. primigenius.
C. elaphus.	Equus caballus.	

NOTE.—*Canis lupus* is found in the Table under the locality "Tewkesbury."

Table of the Localities of the Drifts of the Avon Valley and adjoining Districts, with their Heights above the Sea*.

Upper Series, ranging from 430 feet to 300 feet above the level of the sea.

Localities.	Letters of reference.	Approximate Height above sea-level.	Approximate Height above the river.
		ft.	ft.
Environs of Rugby (maximum height) ...	A, B, D.	380	89
Stretton, near Dunsmore (vicinity of)......	B, D.	350	75
Kenilworth Common	A ?.	325	60
⊕ ?Snitterfield, near Warwick	B, C, D, E.	300	112
Welcombe Hill, near Stratford-on-Avon...	B, C, D, E.	351	211
Brick-yard near the New Inn, "the Ridgway"	B, C, D, E.	430	390
Weethley and Cook's Hill....................	B, D.	350	250
Oversley Upper Lodge farm, near Alcester	F.	310	190
Church Lench..................................	D (G, F ?).	355	305
Cracombe Hill, near Evesham	F.	370	320
Sheriff's Lench	F.	350	310

Lower Series, ranging from 300 feet to 60 feet above the level of the sea.

Localities.	Letters of reference.	Approximate Height above sea-level.	Approximate Height above the river.
Welford and Weston Holes, near Stratford	F.	224	124
Berry's Coppice, Donnington	G.	280	180
Green Hill, Evesham	G.	200	120
Knowle Hill, Evesham (brick-yard)	G.	160	80
Charlton Hill	? G or F.	160	103
Cropthorne Heath	G.	120	70
Cropthorne Hill (summit of)	G.		
Brick Hill, near Pershore	G.	120	80
Mount Pleasant, Pershore....................	G.	150	110
**Beckford	I.	140	110
- Bredon's Norton..............................	I.	120	70
Bredon...	G.	104	67
Shuthanger and Shoebarrow Commons, Tewkesbury	G.	114	88

Freshwater Series, ranging from 274 feet to about 30 feet above sea-level.

Beds of gravel and sand from between Rugby and Stoneleigh to near Tewkesbury, ranging from about 10 feet in the upper valley, to 40 feet in the lower valley, above the existing river.
Modern alluvium from Rugby to Tewkesbury.
Brickearth at Bengeworth and Bricklehampton Bank near Cropthorne.
Peat-bed at Chadbury.

* The heights above the river are measured from the point nearest to the locality. The sign ** indicates the presence of marine shells and mammalian remains ; ⊕ indicates mammalian remains without marine shells.

Part II. The Superficial Deposits of the Severn valley and adjoining District.

Introductory Remarks.—In order to carry out the object I had in view at the commencement, of making the descriptions of the facts belonging to the subject of this paper in a great measure supplementary to those of others, I shall limit myself, as much as possible, to a statement of such of them as I believe have not yet been brought under the notice of the Society.

Literature of the Subject.—Sir Roderick Murchison, I believe, first brought under the notice of geologists, in the 'Silurian System,' the discovery of marine shells and mammalian remains in the drift of the Severn Valley, near Worcester; but, as far as I am aware, no detailed account of the facts connected with the nature and mode of occurrence of the gravels and clay of the Severn valley and its neighbourhood was published until a paper appeared (in the Quart. Journ. Geol. Soc. 1864, vol. xx. page 130) entitled "Notes on the Drift Deposits of the Valley of the Severn in the neighbourhood of Coalbrook Dale and Bridgnorth," by Mr. Geo. Maw, F.G.S., in which, after mentioning the names of other geologists in the same field, the author described some remarkable sections of deposits containing marine shells.

At page clxvi of the Strickland Memoirs the following passage occurs :—" Dr. Falconer conceives that there exists in the valley of the Severn an old *fluviatile* Pliocene deposit of great extent, containing the usual association of Pliocene mammalia—*Elephas antiquus, Hippopotamus major*, Bison, Deer, &c., with freshwater shells; and also *overlying* beds of gravel, which are described as Estuarine, and drift-gravel containing a few marine shells; *Cardium* and *Turritella*, and the mammalian remains of the Glacial period—*Elephas primigenius, Rhinoceros tichorhinus*, Reindeer, Horse, &c." See Dr Falconer's views (Proc. Geol. Soc. 1856–57, page 5, &c.). Wishing to refer, if possible, to the original remarks of so eminent an authority as the late Dr. Falconer, I sought for the reference given, but without finding there any allusion to the subject of the foregoing quotation. I then wrote to Sir W. Jardine, who informed me that the reference alluded to was to be found in vol. xiii. page 307 of the Journal; but up to the present time I have failed to discover it.

Referring to the account of the Severn valley and its geological features between Shrewsbury and Bridgnorth, given in the paper by Mr. Maw, already mentioned, I need only add that below Bridgnorth the river continues its general S.S.-easterly course as far as Tewkesbury, passing over beds of New Red marl for a great part of the distance. As we approach the town of Worcester the valley opens out into a broad undulating vale, about 7 miles in width, extending from the base of the Malverns on the west to the narrow watershed on the east, which separates it from the valley of the Avon. The tide rises up as far as Tewkesbury; but the Severn, like its affluent, the Avon, is much altered in its natural course by locks and weirs.

Drifts of the "Upper and Lower Series."—Between Shrewsbury and Bridgnorth these consist for the most part of (1) Upper gravel and sand, (2) Unstratified sandy clay "with muddy gravel," (3) Lower gravel and sand. According to the observations of Mr. Maw, the greatest vertical development of them occurs at Stret-hill, near Ironbridge, where the beds (no. 2) attain a thickness of 70 feet. At Frankwell, Shrewsbury, a locality where marine shells are found in considerable abundance, the following section of the beds is displayed in a sand-pit near the Ferry, on the south side of the Severn.

	ft.	in.
(1) Vegetable soil	2	0
(2) Fine grey-coloured gravel and sand, with a few large pebbles	1	3
(3) Dark- and light-coloured red sand, with thin layers of fine grey-coloured gravel and sand (in places false-bedded)	5	0
(4) Compact mass of coarse and fine muddy gravel, with a discontinuous band of light-red sandy clay, about a foot thick, containing in places portions of light-brown clay	15	0
(5) Alternate seams of light-red and grey-coloured sand (in parts laminated), in which occur layers of fine grey shingly gravel, with lenticular-shaped masses of the same	25	0
Bottom of pit.		
	48	3

The above Section must be considered only approximately correct as regards the thickness of the beds, on account of the loose, uncompact nature of the sands and gravel, which, falling down from above, form a talus obscuring the face of the section. Between the beds nos. 4 and 5 I observed two large angular blocks, about one foot apart, lying on the surface of the sand; and I was told by one of the workmen that a large rounded boulder of grey granite, which I found lying at the bottom of the pit, had fallen from the same level. At the north-west end of the pit, near the surface of the ground, was seen a compact mass, exhibiting alternate layers of dark red sandy clay and dark red sand, in which signs of contortion were marked. I observed a few small pebbles sticking in it, but no boulders. In the heaps of gravel at the bottom of the pit were numerous scratched pebbles, and small boulders, many of which were flat on one surface. The marine shells, some of which were entire, but most of them fragmentary, appeared to occur chiefly in the light-grey-coloured shingly gravel. On the occasion of a third visit to the spot, a clearing away of a large talus of débris towards the west side of the pit exposed a thick deposit (no. 5) of bright-red sand, containing but few seams of shingly gravel.

As examples of the general character of the deposits in the neighbourhood of Worcester, I have selected those found in the gravel-pits of Kempsey and Hawford Bridge.

Section in gravel-pit, Kempsey.

	ft.	in.
Surface of ground.		
(1) Light-red loam, with a few pebbles	2	0
(2) Dark-red loam and pebbles	2	0
(3) Dark-red sand	0	3
(4) Fine light-red sand and gravel	1	10
(5) Light-red sand	0	3
(6) Fine light-red sand (obliquely laminated) and gravel	1	0
(7) Dark-red sand	0	3
(8) Fine light-red sand (laminated obliquely), gravel, and large pebbles	1	0
(9) Red sand	0	3
(10) Fine light-red gravel and sand (obliquely laminated)	1	6
(11) Red sand, containing lumps of red marl	0	9
(12) Fine gravel and sand, containing a large proportion of greenish-coloured pebbles, with many large pebbles intermixed	2	0
(13) Clean red sand and shingly gravel, containing pebbles about the size of a bean	1	6
Uneven surface of basement rock of red marl.		
	14	7

Section in a gravel-pit near Hawford Bridge.

	ft.	in.
A compact bed of gravel, made up of large and small pebbles of the ordinary type; and dark-red loamy sand. In the upper part of the bed were carbonaceous seams, about 2 inches thick, dipping at a slight angle towards the river	15	0
New red marl.		

Composition of the gravel.—The pebbles which form the chief constituents of the gravels of the Severn valley between Bewdley and Tewkesbury are composed of a greenish slaty-coloured rock, containing veins of white quartz, the presence of which distinguishes them in great measure from the "general quartzose drift" of the Avon district, of white quartz, felstone, and a few flints. The occurrence of boulders and pebbles of grey pophyritic granite is most frequent in the upper portions of the valley.

Modern alluvium.—This deposit appears to be the only one of proved freshwater origin which has hitherto been found in the Severn valley between Shrewsbury and Tewkesbury. It consists of a bed of silt, to all appearance like that of the Avon valley. Mr. Maw has kindly supplied me with the following details of a boring made near the edge of the river's bank, close by Buildwas railway bridge.

	ft.	in.
(1) Vegetable soil	1	0
(2) Stiff loam (Loess)	8	6
(3) Running sand	2	0
(4) Gravel similar to that at Buildwas station. Freshwater mussels	4	6
	16	0

Basement rock Wenlock shale, at a depth of 7 ft. below the river's surface.

TABLE OF THE LOCALITIES OF THE DRIFTS OF THE VALLEY OF THE SEVERN AND ADJOINING DISTRICT, WITH THEIR HEIGHTS ABOVE THE SEA.

Upper Series, ranging from 800 *feet to* 300 *feet above the level of the sea.*

Localities.	Approximate	
	Height above sea-level.	Height above the river.
	ft.	ft.
Burton, near Much Wenlock, Salop	800	780
*Willey Park, near Broseley	460	360
*Strethill, near Ironbridge	300	200

Lower Series, ranging from 300 *feet to about* 50 *feet above sea-level.*

*Frankwell, Shrewsbury	280	130
Berrington, Salop	250	100
*Leighton, near Buildwas, Salop	260	160
*Buildwas	270	170
*St. James's Pits, Bridgnorth	250	170
*Quat, near Bridgnorth	220	140
Spring Grove, Bewdley	250	140
Railway-cutting, near Bewdley	250	140
(Mount Pleasant, near Bewdley)	300	190
Burlish Common, Stourport	150	90
Hartlebury Common	94	35
Hawford Bridge	98	50
Barbourn, Worcester	100	52
*Northwick, Worcester	90	40
Perdswell, Worcester	90	45
**Bromwich Hill, Worcester	86	36
Road-cutting, Langham Brook	95	45
Cutting of Worcester and Hereford Railway	110	70
**Powick, near Worcester	80	55
Two cuttings on the Leominster Railway	160 120	135 115
*Kempsey, near Worcester	57	25
Pisham Ferry	55	23
**Fleet's Bank, Sandlin, near Malvern	270	220
Clifton, near Worcester	60	25
*Upton-on-Severn (Railway Station)	63	25
Tunnel Hill, Upton-on-Severn	100	70
Ripple, near Tewkesbury	60	30
Pull Court, Tewkesbury	180	150
⊕Great Malvern (Railway Hotel)	270	240

Fluviatile Series, ranging from 150 *feet to* 30 *feet above sea-level.*

Modern alluvium, with underlying beds of gravel and sand, containing freshwater mussels.

Marine shells and Mammalian remains.—A carefully compiled list of the marine shells from the drift at Strethill is given in Mr. Maw's paper before mentioned. In the foregoing table of localities I have distinguished them by the following marks:— * * Marine shells and Mammalian remains; * Marine shells without Mammalian remains; ⊕ Mammalian remains without marine shells. They represent the substance of the information which I have derived from various sources, and the truth of which may require verification. The localities where marine shells have been hitherto most abundantly met with are situated between Shrewsbury and Bridgnorth, whilst the mammalian remains have been at present confined exclusively to the part of the valley lying between Worcester and Tewkesbury—the intermediate area between the St. James's pits below Bridgnorth and Northwick near Worcester not having yielded any recorded examples of either class of remains, as far as I have been able to ascertain. According to Mr. Maw's account, fragments of shells were found in the sandy unstratified clay at Strethill. In the museum at Worcester are a few fragmentary specimens labelled *Turritella communis, Purpura lapillus, Cyprina islandica*, &c., which were procured by the late Mr. Jabez Allies, of Worcester, from Kempsey, Bromwich Hill, &c. I have myself collected a few fragmentary shells from the grey shingly gravel and sand at Kempsey and Upton-on-Severn. Mr. Allies, in a pamphlet on "Particulars of a Stratum of Coal at Powick and Bromwich Hill," mentions that at the latter place "a fragment of a bone of some large animal, which lay on the top of the marl (Red), together with a rhinoceros's tooth, and several recent species of marine shells, were dug out from the bottom of the gravel, at a depth of about 12 feet from the surface." He also says that "four teeth of a rhinoceros have been lately dug out from the bottom of a pit at Fleet's Bank, Sandlin, besides sea-shells, a coronary bone of a horse, teeth, and a fragmentary horn of a deer."

Some years back, portions of a tusk, and teeth of a species of Elephant were dug out on the site of the Imperial Hotel, Great Malvern. According to Prof. Dawkins's list, the remains hitherto found in drift beds of the Severn valley belong to the following species of Mammalia:—*Rhinoceros tichorhinus* and *Elephas primigenius.*

Recapitulation of the principal Facts.—Commencing with the Avon valley and district, I have endeavoured to show that the Blue Lias clay of the higher ground, for some distance on each side of the valley, and in some of the minor valleys near Rugby, is covered extensively by a Boulder-clay, above which is found a stratified deposit of quartzose flinty gravel, whilst beneath it a thick bed of finely laminated sand forms the lowest stratum hitherto discovered. In the district of the New Red marl, a red unstratified sandy clay, and beds of quartzose gravel containing a few flints, are found in place of the purple-coloured Boulder-clay and stratified flinty gravel above referred to, underneath which the laminated sand occurs also as far as the hills of Cracombe and Charlton. On the north

side of the main valley, between Evesham and Tewkesbury, isolated patches of the unstratified quartzose flinty gravel of the lower series occur on its upper edge, at Green Hill, Evesham, and Mount Pleasant, Pershore, whilst over portions of the main valley itself similar beds are distributed at elevations varying from 103 feet to 67 feet above the river. At the southern base of the same part of the main valley, stratified deposits of "Local Drift" are met with, containing a small percentage of quartzose pebbles, flints, and quartzose sand, as at Beckford, where marine shells and mammalian remains have been found. They appear to extend around a considerable portion of the lower part of Bredon Hill, and may perhaps be considered to form a sort of link serving to connect the unstratified gravel of the lower series of the Avon district with the stratified beds of the Severn valley which contain marine shells and mammalian remains. I have also attempted to show that the freshwater beds of gravel and brick-earth constitute platforms, divided throughout their length by the present river, but capable of being classed as one deposit, which appears to me distinguishable from the adjacent unstratified beds of the lower series.

On reviewing the phenomena presented by the drifts of the Severn valley, we find, for the most part, but little resemblance between them and the superficial deposits of the Avon valley and district. In some localities there are compact beds of loamy gravel, rarely containing marine shells, which somewhat resemble the unstratified drifts of the lower series in the Avon valley. In others we encounter cleanly washed stratified sands and gravels, such as have not been found in any part of the Avon district. The absence of any deposit resembling the freshwater gravels and brick-earths of the Avon valley and some of its tributaries is remarkable, their position with regard to the river being occupied in the Severn valley by beds containing a few traces of marine shells and, occasionally, mammalian remains.

Remarks on the Evidence bearing upon the origin of the Freshwater Gravels of the Avon Valley.

Leaving out of the question any speculative attempts to correlate the drifts of the upper and lower series in the districts of the Avon and Severn, as being premature in the present state of our knowledge of the subject, I propose to confine the following observations to the evidence deducible from the facts already known regarding the probable conditions which gave rise to the accumulation of freshwater gravel in the Avon valley. The supposition, made by Strickland, to explain the occurrence of gravel containing freshwater shells and mammalian remains at Eckington and Defford, and its connexion with the unstratified quartzose flinty gravel at Bredon, is as follows:—"I can offer no other explanation than that formerly proposed, viz. that after the beds of marine gravel had been deposited where we now find them, and had been laid dry by the elevation of the land, a large river, or chain of lakes, extended

down the valley of the Avon, at a height of from 20 to 50 feet above its present course, and that the gravel previously brought into the district by marine currents was remodified by the river-stream, and mixed up with the remains of the mammalia and mollusca which tenanted its banks or its waters" (see Brit. Assoc. Reports, vol. vi. Sections, p. 64). I submit that the above view may be extended to other portions of the same area. Thus there appears to be evidence of:—

(1) A former time when the main valleys of the Avon and Severn existed pretty much in the state in which we now find them.

(2) A period when the greater portion of them were filled up, to a considerable extent, with the drifts of the upper and lower series, during the latter part of which, perhaps when the land was emerging, an arm of the sea occupied the lower portions of the Avon and Severn valleys, reaching probably to a height of from 200 to 300 feet, or thereabouts, above the present sea-level, at which time, we may suppose, with Sir R. Murchison, that the mammalian remains found near Worcester were washed into the ancient estuary from the neighbouring land-surfaces by sudden and local floods, and imbedded along with marine shells in the beds of sand and gravel, the negative evidence of the absence of freshwater shells, coupled with the occurrence of marine shells, preventing our having recourse to fluviatile agency for their transport. At the same time probably, the local drift at the base of Bredon Hill, containing marine shells and remains of mammalia, was deposited.

Towards the close of this period, and probably after the state of things just described had passed away, the sea having receded to about its present position by a further elevation of the land, and the action of the retiring waters having perhaps scooped out channels in the marine deposits in parts of the valleys, leaving eroded surfaces of clay and marl, upon which is found so large a percentage of the mammalian remains, the ancient river Avon brought down detritus derived from the adjacent beds of marine gravel, redepositing it in stratified beds along with land and freshwater shells over the surface of the clay; whilst the river Severn, in its turn, may have borne the detrital matter brought down from the marine deposits of the valley, along its comparatively straight course, towards the sea. This process of removal and redeposition may be supposed to have gone on until the final excavation of the beds of the rivers through the basement clay and marl to depths of about 30 and 50 feet respectively, as evidenced by the banks overhanging the present rivers in various localities, had reduced them to their present levels. Finally, the rivers having attained a state of equilibrium, they deposited the silt and vegetable matter brought down in times of flood, and spread them out in beds of modern alluvium. The foregoing outline of the probable succession of events belonging to the later geological history of the district is, it must be confessed, manifestly imperfect, and inadequate to explain satisfactorily many of the facts, partly owing to the necessarily meagre amount of positive evidence attainable, and partly depend-

ing upon the restricted area of the district under review. In order to explain the lowering of the bed of the Avon by an increased velocity of its stream, Strickland supposes a "further elevation of the land," to quote his words; but it appears to me necessary to call in the agency of unequal elevation, the inland district of Warwickshire having risen more rapidly than the portion nearer the sea, as Sir C. Lyell supposes to have been the case in reference to the denudation of the Loess of the Rhine, if we are to resort to a cause of which, as far as I am aware, no collateral evidence exists.

Concluding Remarks.—It would be interesting to know how far the evidence afforded by the marine mollusca found in the drift of the Severn valley may be able to explain the probable conditions under which the latter was deposited. The late Edward Forbes, in his valuable paper "On the Geological Relations of the existing Fauna and Flora of the British Isles" remarks that, *Littorinæ*, *Purpuræ*, &c. are genera and species definitely indicating, not merely a shallow water, but a coast-line. Regarding the evidence at present obtainable from the mammalian remains found in the beds containing marine shells at Beckford, and in the neighbourhood of Worcester, and those from the freshwater gravels of the Avon and some of its tributaries, it appears that the number of species is much less in the former than in the latter.

In thus venturing to bring the subject of this paper before the notice of the Society, I may perhaps be allowed to state that I have no pet theory to support, and no inclination to throw "small stones" at those of others, my chief object being to leave the subject in such a condition that future observers may be able to take up its further investigation at the point where I have left off.

In conclusion, let me tender my best thanks to many kind friends for their zeal in forwarding the objects of the present inquiry.

Discussion.

Mr. Searles V. Wood, Jun., had long been aware of the existence of both the Chalky Boulder-Clay and the Middle Glacial Sand near Rugby. He pointed out the difference between the fauna of the sands of the Severn valley and that of the Middle Glacial sand of East Anglia, and thought it scarcely possible that the two sands could be identical.

Mr. Gwyn Jeffreys was doubtful as to the authenticity of some of the shells which had been brought to Mr. Maw. The fossil shells from the Severn valley, Wolverhampton, Manchester, and Moel Tryfaen were nearly identical, and indicated raised beaches. He thought it possible that a definite line of such beaches might eventually be recognized through that part of England.

Mr. W. Boyd Dawkins did not consider that Mr. Lloyd had shown any marked difference in the mammalian fauna of the Avon and Severn valleys. He had failed to discover any traces of *Elephas ntiquus* in either.

Mr. Prestwich thought that Mr. Lloyd had probably divided the

superficial beds into too many separate deposits, though the facts brought forward were of great value.

Mr. EVANS mentioned that he had received information of the discovery many years ago of a flint implement in association with the bones of extinct mammals at Lawford. This implement had been exhibited at the time to the Geological Society, but had disappeared after the meeting.

Mr. LLOYD and Mr. WILSON briefly replied.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

POSTPONED PAPERS.

1. Australian Mesozoic Geology and Palæontology. By Charles Moore, Esq., F.G.S.

[Plates X.-XVIII.]

(Read November 10, 1869*.)

The early pioneers of Australian colonization were too intent upon the practical concerns of daily life to give much attention to scientific investigations, and they consequently overlooked many sources of wealth which they have since learnt were within their reach.

The subsequent discovery of the mineral treasures possessed by the Australian colonies has shown the importance of their more minute and careful survey, and has given an impetus to the study of their geological characters.

The first steps in the exploration of a new country would naturally be the determination of the prevailing geological formations; and as time and opportunity permitted their minuter subdivisions would have to be worked out, and correlated with any of their equivalents in other parts of the world.

In this way it was soon established that the chief sedimentary deposits in Australia were either Palæozoic or Tertiary, and it seemed to be the prevailing opinion that the great intermediate formations included in the Mesozoic group, comprising the Triassic, Jurassic, and Cretaceous rocks, were altogether absent.

We have been slowly learning that these conclusions were too hastily arrived at†; and it is at last incontrovertibly established that some of the missing Mesozoic beds are represented on the great Australian continent.

Setting aside the question of the geological age of the coal-beds of Newcastle in New South Wales, respecting which there was a difference of opinion amongst both Australian and other geologists (the Rev. W. B. Clarke considering them to be of true Carboniferous

* For the discussion on this paper see p. 2 of the present volume of the Journal.

† As already shown by the Rev. W. B. Clarke, in his notice of "Marine Fossiliferous Secondary Formations in Australia," Quart. Journ. Geol. Soc. vol. xxiii. p. 7, 1867.

age, a fact which is now generally recognized, whilst by others they were referred to the Jurassic or the Triassic period*), the first positive evidence that was made known of any fossils of Mesozoic age was through the researches of F. T. Gregory, Esq., who, in a paper on "The Geology of a part of Western Australia," communicated to the Society by Sir Roderick Murchison, and published in the Quarterly Journal, vol. xvii. 1861, p. 475, notices the presence of what he considers Cretaceous rocks in that district. The group, he remarks, partly consists of chalk-like rocks and ferruginous sandstone, containing Ammonites, *Trigoniæ*, and Pectens. "The bed of the Greenough river," he states, "is the best spot for procuring specimens, although a few are to be found in the chalk-hills near Gingin (spines of Echinoderms &c.)." The specimens exhibited at the reading of Mr. Gregory's paper are now in the possession of the Geological Society, and consist of a single cast of *Trigonia Moorei* (Lycett), and a very much worn *Pecten*, of uncertain species, both evidently of Oolitic age. They were accompanied by a *Ventriculites* in flint, and a portion of a chalk Ammonite, and also by a considerable number of specimens of the age of the Carboniferous Limestone.

Meagre as was the evidence thus afforded, it was still sufficient to show, for the first time, the presence of two groups of Mesozoic rocks, the Oolitic and the Cretaceous, in Western Australia.

It is not improbable, from the remarks of Mr. Gregory, that the latter are *in situ*; but hitherto we have no record of the actual presence of stratified Oolitic beds. It is probable that the two specimens may have been obtained from the bed of the Greenough River, as they are evidently drifted fossils, a character which will be found to be general with other remains to be hereafter noticed.

The next, and, up to this time, the most important notice connected with the Mesozoic Australian fauna was due to the Rev. W. B. Clarke, and related to the discovery, by Mr. Gordon, in the neighbourhood of Wollumbilla, of a large number of organic remains which will be more fully noticed hereafter. These were to have been in England in time for the last Exhibition, but had not then arrived.

In that Exhibition, however, there might have been noticed a set of fossils, forwarded by Mr. Shenton from the Greenough Flats and other districts of Western Australia, which were not only the most numerous but the best-preserved Australian secondary fossils that had yet been publicly exhibited in this country. These consisted of *Ammonites macrocephalus*, *Belemnites canaliculatus*, *Trigonia Moorei*, and species of *Ostrea*, *Lima*, *Astarte*, *Cucullæa*, *Myacites*, *Rhynchonella*, &c., all evidently of Oolitic types, and identical with species that will be noticed below as occurring in Mr. Sanford's collection. I could not open the cases to give them a very critical examination; but there appeared to be about fifteen species in the series, together with fossil wood, apparently from the same formation. In addition to the above, there was a siliceous cast of a *Micraster* from the chalk, and some vegetable impressions in a cherty sandstone, the age of which I could not recognize. I had hoped to secure these fossils,

* See W. B. Clarke, Quart. Journ. Geol. Soc. vol. xxiii. p. 11.

but found they had already been sold, and I learnt that they were afterwards conveyed to Portugal.

In a paper read at the British Association Meeting at Cambridge, in 1862 (see Report of Transactions of Sections, p. 83), I gave an account of a series of secondary fossils which I had found displayed in a temporary museum at a Meeting of the Somersetshire Archæological and Natural-History Society at Wellington. These had been collected and sent over to this country by Mr. Clifton, a good observer and naturalist in Western Australia. They were exhibited by W. A. Sanford, Esq., F.G.S., of Nynehead Court, who had resided in an official capacity in Western Australia, and they had been in his possession about six months. He informed me that they had been more than twelve months in reaching England, that he had previously seen and examined them in the colony, whilst in the hands of Mr. Clifton, and that he had remarked to him how much they appeared to resemble European forms. They had been in the possession of Mr. Clifton for several years: hence it appears that, although they had not been made known before my paper above referred to, they were really the earliest evidence obtained of the presence of Mesozoic beds on the Australian continent. The Rev. W. B. Clarke has alluded to some of the fossils of this series in papers in the Journal of the Geol. Soc. vol. xxiii. p. 8, and in a contribution to the American Journal of Science for May 1868.

The only addition that has been made to our knowledge of the Australian Secondary rocks and their fauna, since the above, has been the description, by Prof. M'Coy, of a portion of an *Ichthyosaurus*, which he has described under the name of *I. australis*, and which he supposes may be from the Lower Lias. The only account I have seen of this discovery is in the 'Illustrated Australian News' of Sept. 6, 1868, in which are figures of a portion of a head, with the eye well perserved, a part of a paddle, eight vertebræ, and fragments of three ribs. These remains were described by Prof. M'Coy, at a Meeting of the Australian Royal Society—though in the abstract of the paper no description of the locality, or sections of the strata from which it was obtained, are given. When perfect, the specimen, it is stated, must have been about 30 feet long, in which case it would have been nearly equal in size to our largest European species. It would be important to learn, from any associated fossils, whether this is a Liassic species, or if it comes from one of the members of the Oolitic series; for up to this time I have seen no organic remains which indicate a Lower-Lias fauna in Australia, though, as I shall show that the Middle and Upper Lias are there represented, there appears to be no reason why the Lower Lias also should not be found.

Having given the above summary of our knowledge of the Mesozoic geology and palæontology of Australia up to this time, I have now to offer more detailed evidence on these points; and I shall demonstrate the existence of a Secondary fauna in Western Australia and in the Queensland colony, much larger than has hitherto been supposed.

Western Australia.—Like the organic remains sent by Mr. Shenton to the Exhibition in 1862, those forwarded by Mr. Clifton to Mr. Sanford were unfortunately unaccompanied by any precise description of the beds, or the locality from which they were derived. Mr. Sanford informs me he believes the latter were obtained near either Shark's Bay or Champion Bay, Western Australia, his strong impression being that they are from the former locality. In this case their locality would be nearly 150 miles north of the Greenough Flats, from which districts the specimens sent by Mr. Shenton to the Exhibition were said to have come. Mr. Sanford also informs me that a soft limestone deposit extends in this district for some distance nearly parallel with the coast, lying on older gneiss and Palæozoic rocks, which, in the interior, contain copper and lead. He believes, from information he received, when in the colony, from Mr. Gregory and others, that this limestone may also be found in many places on the coast itself*.

On first examining the specimens from Western Australia, I at once observed that their matrix presented different lithological characters, such as might be expected to occur with remains derived either from various beds in the same geological formation, or still more probably should they have been obtained from formations of different geological ages. Mere lithology is not always a safe guide, and the less so when beds have to be correlated from points so wide asunder as Australia and England: but in this instance there could scarcely be a mistake; and even had no distinctive fossils been present, a geologist acquainted with the secondary rocks of England and Europe could hardly have failed to refer the greater number of the specimens to the horizon of the Lower Oolitic rocks. Associated with these were Upper-Lias species, whose matrix was perfectly identical with a ferruginous or variegated limestone of the Upper Lias occurring near Bath, where it is only about two feet in thickness. And the Middle Lias or Marlstone was not left unrepresented; for from this formation *Myacites liassianus*, Quenst., and a *Pholadomya* occur.

The Middle Lias is the formation from which, in the north of England, such an enormous quantity of iron is being manufactured, the beds yielding an average of 32 per cent. of metallic iron. It is not a little remarkable that this comparatively thin horizon of the earth's crust should, at the antipodes, present similar mineralogical conditions. I have had portions of two of the blocks analyzed; one of them gave 49 and the other 56 per cent. of metallic iron. In this way, lithologically, and almost without the evidence of the fauna they contain, the Western-Australian specimens might be decided to be contemporaneous with the Lower Oolites and the Upper and Middle Lias of this country, from which they are 16,000 miles separated.

The separate blocks or specimens in my possession from Western Australia are about sixty in number, and include many duplicates

* These limestones are referred by Mr. Gregory, though with some doubt, to the Cretaceous series. (Quart. Journ. Geol. Soc. vol. xvii. 1861, p. 477.)

of species. A single block of stone, about 10 inches by 6 inches, from the Oolite, shows that the deposit from which it was derived must have been very fossiliferous; for within this space I have been able to detect as many as thirty species, belonging to the genera *Ammonites, Belemnites, Trigonia, Pecten, Lima, Cucullæa, Avicula, Turbo,* and other univalves, *Rhynchonella, Teredo, Pentacrinus,* &c. The shells are crowded upon one another in the greatest abundance, the bivalves being generally in single valves, showing that they were probably not deposited under tranquil conditions, or that they were not immediately covered up; and the same may be inferred from the somewhat worn character of the fossils, which, in some instances, prevents their specific determination. With all the Australian Secondary deposits that have come under my notice much drift-wood is found; and this, in some instances, has become mineralized and converted into iron-ore. The block of stone above mentioned contains the impression of a piece of wood which has since perished; but a colony of *Pholadidæ*, which had originally burrowed into it, still remained, about thirty of the shells, though in bad condition, being present. I propose for it the name of *Teredo australis*; and it appears to be the oldest representative of the genus yet known.

On examining the series from Western Australia, not only is the similarity in lithological character of the beds with those in this country to be recognized, but the specific identity of many of their fossils cannot be doubted. I was especially gratified at recognizing amongst them such typical and well-known forms as *Ammonites Moorei*, Lycett (Pl. XV. fig. 1), *A. radians* (Pl. XV. fig. 2), *A. Walcottii**, and *Nautilus semistriatus* of the Upper Lias, whilst *A. Brocchii*, *Belemnites canaliculatus* &c., represent organisms from the Inferior Oolite. *Lima proboscidea* and *Ostrea Marshii* appear to have been as abundant as in the hills around Bath; and *Pecten cinctus* from Australia attains the same large proportions as in this country. The Cornbrash is apparently represented in Australia by *Ammonites macrocephalus* and *Avicula echinata,* and the Middle Lias by the *Myacites liassianus* before mentioned. It should be remarked that, as the Australian Oolitic species which are common to this country range from the Inferior Oolite to the Cornbrash, and as they are mostly found associated in the same rock in Australia, it is possible either that some of the species have a longer range, or that our separate divisions may not be there so clearly represented. Nothing is yet really known of the sections from which the fossils come.

It will be seen from the above, that the organic remains have enabled me to determine, for the first time, the presence in Australia of the faunas of the Middle and Upper Lias and the Lower Oolites; and when I come to the Queensland fossils, equally satisfactory evidence will be adduced to show that the Upper Oolites are also represented on the Australian continent.

Out of the comparatively small number of specimens that have

* Another locality in Western Australia, yielding Ammonites, is to the N.N.E. of Wizard Peak, the Rev. W. B. Clarke having sent me photographs of *A. radians* and *A. macrocephalus* from thence.

come into my hands from Western Australia, twenty at least are species identical with those of this country; and had it not been for the worn and abraded exteriors of many of the others, there is no doubt that the list which follows might have been extended :—

Organic Remains common to England and Western Australia.

Ammonites aalensis, var. Moorei, *Lycett*. Upper Lias.
—— radians, *Rein.* Upper Lias.
—— Walcottii, *Sow.* Upper Lias.
—— macrocephalus, *Schloth.* Oolite.
—— Brocchii, *Sow.* Oolite.
Nautilus semistriatus, *D'Orb.* Upper Lias.
Belemnites canaliculatus, *Mill.* Oolite.
Gresslya donaciformis, *Goldf.* Upper Lias.
Myacites liassianus, *Quenst.* Middle Lias.
Cucullæa oblonga, *Sow.* Oolite.
Pholadomya ovulum, *Ag.* Oolite.
Avicula Münsteri, *Goldf.* Oolite.
—— echinata, *Sow.* Oolite.
Pecten cinctus, *Sow.* Oolite.
—— calvus, *Münst.* Oolite.
Lima proboscidea, *Sow.* Oolite.
—— punctata, *Sow.* Oolite.
Ostrea Marshii, *Sow.* Oolite.
Rhynchonella variabilis, *Schloth.* Oolite.
Cristellaria cultrata, *Montfort.* Oolite.

Of the new species associated with the above, the most important, from its apparently great abundance in all stages of growth, is the *Trigonia Moorei*, Lycett, very closely allied to *T. costata*. Fifteen, more or less perfect, separate valves of this shell may be counted in a single block. The single valve presented by Mr. Gregory to the Geological Society, and the example sent by Mr. Shenton to the Exhibition from the Greenough Flats, belong to this species. Knowing the interest felt by Dr. Lycett, of Scarborough, in this group, I forwarded the specimens to him, and he has favoured me with the description appended to the species.

The Lamellibranchiata appear to have formed a very marked feature in the Western Australian fauna, about twenty genera being represented in the collection. Besides those already mentioned, *Cucullæa, Myacites, Astarte,* and *Avicula* are the most abundant. The matrix with which their valves is filled may be seen to be crowded with Encrinital remains, spines of *Echini*, and other small organisms, but for the most part so worn as not to be recognizable.

Of the Gasteropoda there are five or six genera, but nearly all in very bad condition. The Brachiopoda are represented by a single species, *Rhynchonella variabilis*, of which there are many examples; the Entomostraca by a single species; and the Foraminifera also by a single species of world-wide distribution, the *Cristellaria cultrata*.

Unfortunately, with all the Australian fossils there is an absence of sectional details. The fact of the separate blocks having organic remains representing several European formations, and the abraded and water-worn condition of many of them, lead to the conclusion

that they were not obtained from the parent rock. It is most probable that they were found either in a boulder- or drift-deposit, or, like those of Mr. Shenton, in the bed of some dry creek or river. This opinion is strengthened by the fact that the surfaces of many of them must have been exposed, as they are still covered with recent lichens.

General List of Organic Remains from Western Australia.

Plantæ.
Cliona (?).
Cristellaria cultrata, *Montf.*
Echini (spines).
Serpulæ.
Entomostraca, sp.
Polyzoa, sp.
Rhynchonella variabilis, *Schloth.*
Avicula Münsteri, *Goldf.*
—— echinata, *Sow.*
—— inæquivalvis, *Sow.*
Lima proboscidea, *Sow.*
—— punctata, *Sow.*
—— duplicata, *Sow.*
——, sp.
Lima, sp.
Ostrea Marshii, *Sow.*
——, two sp.
Plicatula, sp.
Pecten cinctus, *Sow.*
—— calvus, *Münst.*
—— Greenoughiensis, *Moore.*
Astarte Cliftoni, *Moore.*
—— apicalis, *Moore.*
——, two sp.
Cardium, sp.
Cucullæa oblonga, *Sow.*
——, three sp.
Cypricardia, sp.
Gresslya donaciformis, *Ag.*
Isocardia, sp.
Myacites liassianus, *Quenst.*
—— Sanfordii, *Moore.*
——, two sp.
Pholadomya ovulum, *Ag.*
Teredo australis, *Moore.*
Tancredia, sp.
Trigonia Moorei, *Lycett.*
Unicardium, sp.
—— (?), sp.
Amberleya, sp.
Cerithium, sp.
Eulima (?), sp.
Phasianella, sp.
Trochus, sp.
Turbo lævigatus, *Sow.*
——, sp.
Rissoina australis, *Moore.*
Ammonites aalensis, var. Moorei, *Lycett.*
—— radians, *Rein.*
—— Brocchii, *Sow.*
—— macrocephalus, *Schloth.*
—— Walcottii, *Sow.*
——, sp.
Nautilus semistriatus, *D'Orb.*
Belemnites canaliculatus, *Schloth.*

Queensland Mesozoic Fossils.

The next series of organic remains to which I shall refer are, from the variety they present, of considerable interest. They have all been forwarded to me by the Rev. W. B. Clarke, F.G.S., of St. Leonard's, New South Wales. They would have been described some time since but for the difficulty attending the determination of their precise geological age, and my desire to be furnished with additional specimens, and especially with samples of any clays or marls with which they might have been associated, for minute examination. Long droughts, however, and other unforeseen circumstances have prevented their reaching England before.

Although a few specimens have been added by the Rev. W. B. Clarke, the series I have to notice is the same that was placed in the hands of Professor M'Coy for determination by his Excellency Sir Henry Barkly, when Governor of Victoria. [They were included in a list (nos. 1–50) published in 'Recent Geological Discoveries in Australia,' by the Rev. W. B. Clarke, p. 50.]

Professor M'Coy remarks on the interest attaching to this series

of fossils as showing the existence of a distinctly marked marine fauna in Australia, and then goes on to say that "the general aspect or facies of the *Serpulæ*, Brachiopoda, *Lima*, &c. is exactly that of those of the base of the Oolite and Lias beds, whilst some of the *Monotis* recall the Saliferous beds of Germany." "Perhaps," he adds, "one of the most interesting points in my examination of these fossils is my determination of Professor Bronn's genus *Myophoria* (nos. 23, 24, 29), so abundant in the Muschelkalk of Germany, strengthening my general reference of the whole to the base of the Mesozoic series, as well as suggesting, for the first time, the existence of the Muschelkalk in Australia, the only European formation wanting in England." His view of the general series was that they are "not younger than the base of the Oolite, nor older than the Trias."

The Rev. W. B. Clarke at the same time suggests (p. 52) the possibility of this group of fossils belonging to the Rhætic formation, and of the small fish-teeth found with them being identical with those found by myself in the Rhætic fissures near Frome. The evidence that will be adduced will show that neither of the above conclusions is correct, and that the whole series must be assigned to a higher position in the geological scale.

The locality from which most of the specimens come is Wollumbilla, on the east side of the Fitzroy Downs, whilst a few are from the Fitzroy Downs, the Mitchell Downs on the Amba river, the downs on the Nive river, the Upper Maranoa west of Bendango, Mount Abundance, Blythesdale, and Bungeeworgorai, all in the Queensland colony. The Rev. W. B. Clarke has also forwarded me a photograph of a *Cytherea* from the Gregory River, a few miles north of Finnis's Springs, on Stuart's Route from Adelaide to Chamber's Bay.

As in the case of the remains already noticed from Western Australia, there appears to be little room for doubt that those now under consideration have not been obtained from their parent bed *in situ*, but from the sides or beds of creeks, and from derived boulders scattered over the face of the Queensland Downs.

As there are 38° of longitude between the district from which the Liassic and Oolitic specimens from Western Australia come and that of Wollumbilla, throughout which space as yet no Secondary beds appear to have been found *in situ*, we have evidence (which is also confirmed by the general character of the Australian continent) that there must have been an enormous denudation of the Secondary series over a considerable part of its surface between the deposition of the Palæozoic rocks and that of the Tertiary beds, the missing members of the Secondary series being as yet only made known to us by the comparatively meagre evidence afforded by the series of Mesozoic fossils now under consideration.

In his 'Recent Geological Discoveries in Australia' (p. 52), the Rev. W. B. Clarke states that the Wollumbilla fossils occur in rounded, nodular, or concretionary boulders imbedded in a brittle marl in the creeks and on the downs, which are covered by grits

and sandstones, mostly red, and evidently partly fused by igneous action. The calcareous sandstone occurs along the creeks and downs where water has denuded it; and above all is a coarse grit. The descending section in the creek-bank, where the fossiliferous nodules occur, at Wollumbilla is as follows:—

1. Brown stiff soil, full of pebbles of quartz much water-worn.
2. Clay.
3. Slate-coloured marl, very friable above, but hard below, charged with strings of crystalline carbonate of lime, and breaking into rectangular fragments. In this occur the calcareous masses. On the east, at about three miles distance, coarse conglomerates rise above these beds; and to the west, coarse alluvial sand occurs. The height of the section is about 15 feet; the bluff end of the conglomerate rises to about 20 feet, and from it to the surface slopes away to the eastward, the stratification being apparently horizontal.

It is not improbable, I think, that the metamorphosed condition of the sands and grits referred to above may be due to mineralogical rather than to igneous action.

The calcareous boulders from the Wollumbilla Creek, when broken, are found to be of a deep olive colour internally, a few presenting a dull brown or bluish hue. They are very compact. In all of them organic remains are very abundant. The exteriors of many of the boulders are very much water-worn, and exhibit only sections of the organic remains they contain; whilst in others a certain amount of decomposition or oxidation of the surface has taken place, which has produced a rotten exterior, looking like an impure chalk, of a yellow or buff colour. When this is the case, the fossils stand out sharply from the matrix. An examination of the softer portions thus produced, has enabled me to detect the presence of Foraminifera (of nine European species) and Entomostraca, and many other remains which had not previously been recognized. One block of stone may be seen to be perforated in every direction by *Serpulæ*; and there are to be recognized over its surface small teeth of fishes, *Rhynchonellæ* of several species, *Argyope*, *Nucula*, arms and scattered plates of *Pentacrinites*, *Natica*, *Pecten*, *Avicula*, &c.; whilst masses of *Purisiphonia*, a new genus of fibro-siliceous Sponges, which have resisted the decomposing action to which the blocks have been subjected, appear to be abundant. Other blocks seem to be almost composed of the detached valves of Conchifera, with an occasional Belemnite. From Maranoa there are examples in which the bed is seen to be almost made up of rolled and broken Belemnites, intermixed with small pebbles; whilst another from the Downs on the Nive river contains nothing but a mass of *Mactra*.

As in Western Australia, a quantity of drift wood and vegetable matter is mixed up with the Queensland fossils; and it appears evident, from the broken and abraded Belemnites and the condition of some of the shells, that they could not have been directly covered up, or that the parent beds were not deposited in a very tranquil ocean. One exception, however, to this is presented by blocks containing *Pentacrinites* from Mitchell Downs, which, though subse-

quently abraded, indicate that very beautiful examples of this genus may probably be obtained from that region.

On the surfaces of several of the blocks slight traces of carbonate of copper may be detected, as though they had been in contact with water holding that mineral in solution.

On comparing the general series of fossils, I at once saw that they had nothing in common with the Rhætic beds or any of the Lower Secondary formations; and on referring to the list given by Professor M'Coy of the species determined by him, this was the more apparent. The *Myophoriæ* (nos. 23, 24, and 29) of his list, which unfortunately are not in good condition, and on the strength of which the presence of the Muschelkalk in Australia was affirmed, proved to be *Trigoniæ*, very closely allied to the *T. gibbosa* of the Portland Oolite; a slightly curved tubular shell, referred, but with some doubt, to *Orthoceras*, proved to be a small *Serpula*; nor were any of the species identical, as suggested by Professor M'Coy, with any belonging to the Triassic or Liassic series. Amongst the specimens was a part of a so-called "*Ammonite*" (from the Upper Maranoa); but this I recognized as a portion of the inner whorls of a gigantic *Crioceras*. Another block contained five lobes of the terminal chambers of probably the same specimen, which portion alone measured 14 inches in length; so that the shell must have attained a size exceeding that of any which lived at the Neocomian period.

These and other circumstances indicated a higher horizon for the Queensland fossils; and I now proceed to give those of most importance a more detailed consideration, after which I shall endeavour, as well as the difficulties they present will permit, to refer them to their probable geological positions.

Organic Remains from Queensland.

Amorphozoa.—This order is represented amongst the Queensland specimens by a large siliceo-fibrous Sponge, closely allied to *Dactylocalyx*, Stutchb. I have been favoured with a description of it by Dr. Bowerbank, who proposes for it the new genus *Purisiphonia*, and names it *P. Clarkei*, after the Rev. W. B. Clarke, F.G.S., through whose exertions, aided by zealous friends in the interior, the collection of fossils now under notice has been brought together. The specimen has been decalcified by Dr. Bowerbank by means of hydrochloric acid, the skeleton-tissue being in a very beautiful state of preservation.

This form appears not to have been uncommon, as numerous fragments may be detected projecting from the surfaces of some of the blocks from Wollumbilla. It is stated by Dr. Bowerbank that this Sponge has affinities with a group which hitherto has not been found in England lower than the Chalk of Flamborough Head, and that he considers the matrix containing the Sponge to be of a similar character to the hard Chalk of that district. Only the above species is present in the Australian collection. Dr. Bowerbank's notes on the genus are appended hereto (see p. 240).

Foraminifera.—Of this group five genera are represented, the

most abundant form being *Planorbulina Ungeriana.* These *Planorbulinæ* are attached in considerable numbers to the plicated surfaces of *Rhynchonella* and *Argyope.* Of *Cristellaria acutauricularis* there are six specimens; whilst *Polymorphina lactea, Dentalina communis* (?), and *Vaginulina striata* have only yielded one each. As these have been obtained simply by washing the soft surfaces of several of the blocks, it is evident that the group must be abundantly represented in a fossil state on the Australian continent.

Zoophyta.—This group is not represented in the series. The supposed coral (no. 10) of Professor M'Coy's list represents the internal structure of a piece of fossil wood.

Echinodermata.—In examining the decomposed surfaces of the Wollumbilla blocks, I have detected the presence of fragments of the spines of several forms of Echinodermata; and there are also numerous detached plates and portions of the columns of *Pentacrinites.*

Two blocks found on the Mitchell Downs, and recently received by me from the Rev. W. B. Clarke, show that interesting remains belonging to this class will probably be found hereafter in this district, where boulders occur, derived from a bed in great part composed of Pentacrinites.

Polyzoa.—It is not improbable that this group may be numerously represented, as there are frequent indications of Polyzoa; but the worn condition of many of the shells to which they are attached is unfavourable to their preservation. On a cast of a *Cytherea* from the Maranoa river numerous reticulated impressions show that its interior was almost covered with them. Another form also occurs, with long cylindrical cells, belonging to *Lepralia,* which, hitherto, I believe, has not been found below the Red and Coralline Crag.

Brachiopoda.—The Queensland representatives of this group possess considerable interest from the fact that most of the species are new, and several peculiar forms are amongst them. There can be no doubt that the class is strongly represented in the deposit from which these blocks are derived; and it may be anticipated that at a future day more genera and species may be obtained from them. The only species to be recognized is the *Lingula ovalis* of the Kimmeridge Clay, or the *L. subovalis* of the Lower Greensand, which names probably refer to the same species. This shell is most abundant, as many as fifteen examples being visible on the surfaces of a block only two or three inches square. Its presence assists in uniting the faunæ in several of the blocks which contain nothing else in common. Two species of *Rhynchonella* occur, one of them being apparently very abundant. One of these, which I have named *R. rustica,* approaches very closely to *R. concinna* of the Great Oolite and Bradford Clay. A third genus is represented by a shell (with a very finely punctated structure and closely striated exterior) to all appearance belonging to *Terebratella,* under which genus (in the absence of internal structure) it is placed. It is the largest of the Australian Brachiopoda; and I have named it *T. Davidsonii,* after the palæontologist who has spent a life in the elucidation of this

important group of shells. A fourth genus is represented by some very curious *Strophomena*-like shells, belonging to a group formerly placed by Dr. Deslongchamps under *Argyope,* but subsequently removed by him to the Terebratulidæ. The three French species, *A. liasiana, A. Perrieri,* and *A. Suessii,* I have found in England in the Lias, as also a minute shell, the *Spirifera oolitica,* mihi, which will have to be arranged with them. The peculiar form of these shells, their long hinge-lines, compressed valves, and finely folded or plicated exteriors, even in ignorance of the internal form of the loop, are, I think, sufficient to justify their arrangement eventually under a new genus or subgenus. I have two species from Wollumbilla, *A. punctata* and *A. wollumbillaensis.*

All the above Brachiopods occur together in the blocks which yield *Purisiphonia.*

Lamellibranchiata.—The importance of this class in connexion with the palæontology of Queensland is indicated by the fact that the collection includes 22 genera and 36 species; and there are fragmentary evidences of others that would still increase the list. Of this group the Aviculidæ are the most frequent, of which there are eight or nine species. One of these is the *A. braamburiensis,* Phil., of our Oxford Clay, the only shell in this class which can be satisfactorily identified with a European species. Most of the other Aviculidæ from Queensland have a reticulated ornamentation, and evidently belong to the group of which the above shell may be considered a type. Species of *Lima* and *Pecten* are also abundant, one species of the latter genus approaching the *P. retiferus* of the Great Oolite, whilst another is not unlike *P. rigidus* of the same formation. *Cythereæ,* equalling in size any of the Tertiary species, appear also to have been abundant; the most noteworthy of the other genera are *Thracia, Panopæa, Mya,* and *Trigonia,* to which allusion has already been made.

Gasteropoda.—Seven genera, including ten species, occur in Queensland, the prevailing shell being *Natica variabilis.* The others are generally represented by solitary examples, the worn state of some of which prevents specific comparisons.

Cephalopoda.—No trace of any Ammonites, which are so abundant in the Western Australian beds, appears in the collection from Queensland. The specimen, the inner whorls of which were referred to that genus, is a gigantic *Crioceras,* which exceeds in size any specimen I have ever seen from Neocomian strata, wherein that genus attains its largest dimensions. This specimen is in a dark-blue limestone matrix, and the portions preserved retain their test; but unfortunately, except a crushed *Rhynchonella,* there are no other remains associated with it to assist us in arriving at its precise geological age.

The only other genus is *Belemnites.* Examples of this occur under three conditions:—1st, as detached frusta, as much water-worn as if they had come from Postpliocene gravels; 2ndly, in blocks having a sandy matrix, containing small pebbles, coloured by manganese (here, again, they were very much broken or abraded before they were

covered up; these are accompanied by *Naticæ* and *Modiolæ*, which, though from the Upper Maranoa district, clearly connect them with the Wollumbilla fauna); and, thirdly, the large phragmacone 6 inches in length, in a matrix of dark-drab or olive limestone, from Wollumbilla, whence also are two small specimens which I succeeded in opening up in a very much water-worn block, with many *Aviculæ* &c.: these, Professor Phillips thinks, may possibly be young examples of the larger form, which he considers to approach *B. paxillosus*, a species ranging from the Middle Lias upwards. Regarding the other species, Professor Phillips remarks that they have stronger analogies with the Upper Oolitic forms than with any other. There is some analogy to the Speeton Belemnites, but scarcely any to the Neocomian species of the South of Europe. Professor Phillips's notes on the species will be given hereafter (see p. 258).

Vertebrata.—Numerous fragments of fish-teeth and scales, and a portion of a small vertebra, occur in the Wollumbilla blocks. They probably belong to *Hybodus* and *Lepidotus*. They are accompanied by some small, depressed, spine-like bodies, which Professor M'Coy supposed might be the hooks of *Cephalopoda*; but these are horny, whilst the former are enamelled, and they are, I have no doubt, of Ichthyic origin.

Résumé.—For reasons already given, there seems to be no ground for doubting that all the organic remains from Western Australia and Queensland noticed in this paper have been obtained from blocks scattered through superficial deposits derived from the denudation of preexisting secondary deposits. That this denudation must have taken place over a great extent of the Australian continent is shown by the wide separation of the districts from which these remains have been collected.

It is very evident that all the Australian fossils which I have had under examination (except some plant- and insect-remains noticed in the following paper, see p. 261) are of true Mesozoic age, though the peculiar circumstances under which they are found necessarily render it very difficult to assign them to their precise geological horizons. Respecting the series from Shark's Bay, the Greenough Flats, and the Greenough River, Western Australia, from the presence among them of Ammonites and other fossils which are the typical species of certain horizons in this country, there seems to be no doubt that they have been derived from the equivalents of our Middle Lias, Upper Lias, and Inferior Oolite. Some of them, such as *Ostrea Marshii* and *Lima proboscidea*, pass up in England into the Fuller's-earth Oolite above; and it is remarkable that, though lithological conditions are not always a safe guide, in this instance the deposits also appear to be identical.

The same satisfactory conclusions, however, are not to be arrived at respecting the series from Queensland, the evidence as to the age of which I now proceed to consider.

The great majority of the Queensland fossils have been obtained from Wollumbilla, and come from the same geological formation. The blocks with the fine *Pentacrinites australis*, from the Amby

river, Mitchell Downs, may reasonably be assigned to the same age, since they contain *Lingula ovalis* or some other fossils in common.

In considering the most typical of this group of Australian remains, which in the whole embraces about 90 species, we have in the first place the *Purisiphonia Clarkei*, the forms allied to which are stated by Dr. Bowerbank not to have hitherto been found below the Lower Chalk of Flamborough Head; but as I have, of this class, lately found the genus *Grantia* in the Lias, though it had never before been found below the Red Crag, the presence of the former genus, though pointing to a Cretaceous horizon, does not necessarily imply it. Five of the *Foraminifera*, at least, are found as low down as the Lias, but they are known to pass upwards into higher formations.

Of the *Brachiopoda*, the *Rhynchonellidæ* are closely allied to Great-Oolite species. The *Argyopæ* have their analogues in those from the Lias; whilst the only species of *Lingula* is no doubt identical with the *L. ovalis* of the Oxford Clay and Upper Oolites.

Among the *Conchifera*, the *Avicula braamburiensis*, again, evidently connects the series with the Oxford Clay, some of the other species of that genus apparently belonging to the same natural group. The *Trigoniæ* have their nearest alliance with those of the Portland Oolite.

Respecting the *Belemnitidæ*, Professor Phillips leans to the conclusion that, with the exception of the large phragmacone allied to *B. paxillosus* of the Lias, the others are more nearly related to Oxford-Clay types than to those of any other formation.

Under these circumstances it is not easy to decide with certainty as to the exact position of the fossils that come from Wollumbilla. The Lias, the Great Oolite, the Oxford Clay, the Portland Oolite, and the Cretaceous beds may each put in a claim; but that of the Oxford Clay appears to be the strongest. That they all belong to the Upper Oolite may with safety be inferred.

There remain the genera *Panopæa*, *Mya*, and *Thracia*, from Bungeworgari and the Amby river, and the gigantic *Crioceras*. From the nature of the matrix, though this does not pass for much, they appear to have been derived from beds of a different character from those from the other districts. As similar *Criocerata* have never been found below the Lower Greensand, it is reasonable to infer the presence of Neocomian beds in Australia*, from whence it may have been derived.

List of Mesozoic Species from Queensland.

Plantæ (wood).
Purisiphonia Clarkei, *Bowerbank.*
Cristellaria acutauricularis, *Ficht. & Moll.*
—— cultrata, var. radiata, *Moore.*
—— acutauricularis, var. longicostata, *Moore.*
Dentalina communis, *D'Orb.*
Polymorphina lactea, *W. & J.*
—— gibba (?), *D'Orb.*
Planorbulina Ungeriana, *D'Orb.*
—— lobatula, *D'Orb.*
Vaginulina striata, *D'Orb.*
Pentacrinus australis, *Moore.*
Echinus (spines).
Serpula intestinalis, *Phil.*

* Unless a large *Crioceras*, said to have been met with near Port Elizabeth, indicates the existence of that genus in the Jurassic beds of South Africa.

Balanus, sp.
Entomostraca, sp.
Lepralia oolitica, *Moore.*
Polyzoa, sp.
Argyope wollumbillaensis, *Moore.*
—— punctata, *Moore.*
Discina apicalis, *Moore.*
Lingula ovalis, *Sow.*
Rhynchonella rustica, *Moore.*
—— solitaria, *Moore.*
Terebratella Davidsonii, *Moore.*
Avicula simplex, *Moore.*
—— æqualis, *Moore.*
—— braamburiensis, *Phil.*
—— Barklyi, *Moore.*
—— substriata, *Moore.*
—— reflecta, *Moore.*
—— umbonalis, *Moore.*
—— corbiensis, *Moore.*
——, sp.
Lima Gordonii, *Moore.*
——, sp.
——, sp.
—— multistriata, *Moore.*
Pecten æquilineatus, *Moore.*
—— socialis, *Moore.*
—— fimbriatus, *Moore.*
——, sp.
——, sp.
——, sp.
Perna gigantea, *Moore.*
Arca plicata, *Moore.*
—— prælonga, *Moore.*
Astarte wollumbillaensis, *Moore.*
Cardinia, sp.
Cardium, sp.
Cytherea Clarkei, *Moore.*
—— gibbosa, *Moore.*
Goniomya depressa, *Moore.*
Leda australis, *Moore.*
Lucina anomala, *Moore.*
—— australis, *Moore.*
Mactra trigonalis, *Moore.*
——, sp.
Modiola unica, *Moore.*
Mya Maccoyi, *Moore.*
Myacites planus, *Moore.*
Mytilus inflatus, *Moore.*
—— rugo-costatus, *Moore.*
—— planus, *Moore.*
Nucula Cooperi, *Moore.*
—— truncata, *Moore.*
——, sp.
Panopæa rugosa, *Moore.*
Tancredia plana, *Moore.*
Thracia Wilsoni, *Moore.*
Trigonia lineata, *Moore.*
Actæon Hochstetteri, *Moore.*
—— depressus, *Moore.*
Delphinula reflecta, *Moore.*
Dentalium lineatum, *Moore.*
Natica variabilis, *Moore.*
—— ornatissima, *Moore.*
——, sp.
Solarium ?, sp.
Trochus, sp.
Turbo, sp.
Belemnites paxillosus (?), *Voltz.*
—— australis, *Phillips.*
——, sp.
——, sp.
Crioceras australe, *Moore.*
Teuthis, sp.
Hybodus ? (teeth and scales).
Lepidotus (scales).

General Table of Secondary Species.

	Nr. of species.
Plantæ	2
Amorphozoa	2
Foraminifera	7
Echinodermata	4
Articulata	4
Crustacea (Entomostraca)	2
Polyzoa	2
	23

	Nr. of species.
	23
Brachiopoda	8
Conchifera	83
Gasteropoda	18
Cephalopoda	13
Pisces	3
	148

Descriptions of New Species.

[Purisiphonia, Bowerbank.

Canaliculated siliceo-fibrous skeletons. Skeletons reticulate, unsymmetrical. Fibres composed of concentric layers of solid silex, with a continuous central canal.

This genus is intermediate in its structure between *Dactylocalyx* (Stutchbury) and *Farrea* (Bowerbank). Like the latter, its fibres

are continuously canaliculated; but it has not any thing approaching the angulated symmetrical arrangement of its skeleton fibres; on the contrary, it very closely simulates the mode of disposition of the fibres that prevails in *Dactylocalyx*. The central canals in the fibres, in the species of *Purisiphonia* on which the genus is founded, occupy from about one-fifth to one-third of the entire diameter of the fibre; they are straight and uniform in their diameter, and have little or no enlargements at their junctions with each other. The reticulations of the skeleton are frequently extremely close, so that the areas do not exceed, or sometimes even equal, the diameters of the fibres bounding them.

1. Purisiphonia Clarkei, Bowerbank. Pl. XVII. fig. 1.

Sponge. Fistulose, branching, surface even. Oscula simple, dispersed over the inner parietes of the fistulæ. Dermis and dermal membrane obsolete. Skeleton stout, closely reticulated. Interstitial cavities furnished with angulated sexradiate spicula?

Loc. Wollumbilla, Queensland, Australia.

Obs. There is much greater difficulty in the specific description of a fossil Sponge than of a recent one, as a considerable portion of the most decisive specific characters are usually absent, in consequence of the decomposition of the softer parts of the organization previously to fossilization; and this is doubtless the case with the specimen under consideration. Although thus deprived of the use of many valuable descriptive characters, there are sufficient remaining to enable us to securely determine its specific identity.

It is difficult to say what was the real form of the specimen in its unmutilated state; but, judging by its present condition, it was originally a large fistular Sponge, giving off fistular branches at irregular intervals. The large fistular body of the Sponge has been split longitudinally, and a portion 4 inches in length, and almost half of the tube of the Sponge, remains; and from the surface of this the entire basal portions of two secondary fistular branches proceed; and there are also the remains of another such branch at the margin of the primary fistula at the right-hand side. The outer surface of the Sponge has an irregular reticulation of stout siliceous fibres, very similar to those of *Dactylocalyx*, immediately beneath the dermis.

In all the recent species of this tribe of siliceo-fibrous Sponges with which I am acquainted, there is a free dermal coat attached to the stiff, non-expansive skeleton beneath, by connecting spicula, cemented at their basal points to the mass of the skeleton by keratode only, and which would naturally be separated from the body of the Sponge, by maceration and decomposition of the keratode, a short period after its death; and none of this dermal coat, it is probable, would appear with the fossil, unless it were to be enveloped and fixed in the matrix in a very short time after its death. This organized envelope usually affords the most distinct and determinative specific characters, and it was very important to discover its remains if possible; but in this attempt I have been quite unsuccessful. In its

living condition this Sponge would probably exhibit a smooth membranous surface; but in its present state we have large open areas exhibited in lieu of the smooth dermal membrane. These areas are in fact the distal ends of the intermarginal cavities, and are usually much larger than the interstitial spaces immediately beneath them. In the specimen under consideration, as in similarly organized recent Sponges, the proximal terminations of the intermarginal cavities communicate immediately with the distal ones of the interstitial spaces, and then, uniting, increase in their size as they progress towards the inner parietes of the great cloacal cavity of the Sponge, into which they finally discharge their streams through the oscula. In this organization they closely resemble the structures in the recent genera *Grantia* and *Verongia*, and many of the fistular keratose Sponges of the West-Indian seas.

I have not detected any connecting spicula; and I have assigned the angulated sexradiate ones to the interstitial cavities on the faith of some very dilapidated remains of them, deeply immersed in the tissues, and rendered visible only by the penetrating power of the Lieberkühn.

The nearest relations to this tribe of Sponges among the fossil ones are decidedly the siliceo-fibrous Sponges of the Flamborough Chalk; and below that formation I am not aware of any such Sponges having been found. The matrix of the Australian fossil also possesses much of the character of Chalk; it dissolves completely in dilute hydrochloric acid, and leaves only a small quantity of sandy residuum.

I may also observe that the similarity of form and structure between the Australian and the English Chalk Sponges in this case is by no means a new fact, as there are abundant instances of similar close alliances existing among the recent Australian Sponges and those of the Chalk-formation of England; and among the most prominent are the existing representatives of *Choanites* and *Ventriculites*.—J. S. B.]

2. Cristellaria cultrata, Montfort, var. radiata, Moore.

This shell, of which I have discovered but one example, possesses the central disk of *C. cultrata*, from which the ribs on the surface proceed; and although the keel is less produced, there appears no doubt it must be referred to this species. From the more radiating character of the costæ, I propose for the variety the name of *C. radiata*. It is from Wollumbilla.

3. Cristellaria acutauricularis, Ficht. & Moll, var. longicostata, Moore.

Shell oblong, moderately biconvex, later chambers passing beyond helicoid portion; surface with ribs which are longitudinally costated.

The typical European forms of *C. acutauricularis*, which are found also with this shell, possess smooth surfaces, and are without the longitudinal costæ,—the difference being so marked as to justify

its separation. I have only seen one specimen, which is also from Wollumbilla.

4. Pentacrinus australis, sp. n. Pl. XVII. fig. 3, and Pl. XVIII. fig. 1.

Pelvis short, compressed, rounded; plates of the body and arms finely rugose; scapulæ thick, supporting 10 arms, composed of 13 plates, the hands bifurcating from cuneiform joints, the fingers being of considerable length, with 40 or more joints of varying thickness, to which are attached lengthened jointed tentacles. Interior of the pelvis disk-like or concave, exhibiting a central pit.

Two specimens of this fine and interesting species are from the Mitchell Downs, on the Amby river; and it is seen by the numerous arms that pass through the block of limestone that a whole colony of them must have been present. One of the specimens is lying on its side (exhibiting the base of the pelvis, with its columnar articulation), whilst three arms, with the base of two others, are exhibited. The second specimen shows the interior of the pelvis, and has the arms flattened out. Each arm, above the scapulæ, appears to have been about 6 inches in length. In a block from Wollumbilla a portion of a column, with 95 regular joints, is present, of probably the same species. Unfortunately some of the connecting joints of the arms have been washed out, though the impressions are left indicating their direction.

Cirripedia (balanus?).

When the tests of the Australian shells are occasionally broken, or casts only are preserved, it may often be noticed that the interiors were covered by Polyzoa, Serpulæ, and other parasitic animals. On the interior of *Panopæa* are two disk-like impressions with fimbriated radiating surfaces; and it was difficult to decide whether they might not be flattened Corals, or even *Craniæ*. On consulting my friend Mr. Etheridge respecting them, he suggested that they might be the places of attachment of *Balani* or some other Cirripeds; and on examining the collection at Jermyn Street, analogous impressions were found produced by the attachment of these shells; so that, although no other traces of the shells have been found, the family may, I think, be added to the list.

5. Lepralia (?) oolitica, sp. n. Pl. XVII. fig. 2.

Cells long, cylindrical, base soon becoming immersed, so as to resemble *Tubulipora* or *Diastopora*. It occurs not unfrequently on the exteriors of the Wollumbilla fossils.

Mr. Busk, who has examined the species, remarks that he has not before noticed it, and that it does not occur in a series (Tertiary) he had examined from Mount Gambier. The *genus* has not hitherto been found lower than the Cretaceous period.

6. Argyope wollumbillaensis, sp. n. Pl. X. figs. 3–5.

Shell compressed, transverse; hinge-line extending the entire

length of the shell; umbones depressed; ventral area extended; deltidium narrow, triangular; exterior of the valves covered with coarse rounded striæ, which are broken at the concentric lines of growth, where they are seen to be hollow, and were probably continued in spines over the folds of the shell; exterior of dorsal valve abruptly keeled, the lines of growth crossing, which give the keel a comb-like appearance; interior of the dorsal valve with a sinus, which terminates at the front of the shell in a deep fold; and it possesses teeth-sockets, cardinal process, and distinctly raised crural plates; ventral valve, in its younger state, rather flat, but becomes concave and closely fitting to the dorsal valve; it possesses a deep sinus corresponding to the depression in the interior of the large valve; edges of the shell closely fitting; internal loop not known.

Shell-structure very finely punctated. This interesting shell is found with the *Purisiphonia* and other remains at Wollumbilla; and as there are evidences of several more or less perfect examples in the block, it must be an abundant shell. It belongs to the group originally arranged by Dr. E. Deslongchamps under *Argyope*, of which he described three species from the Lias, but which, in his 'Paléontologie Française,' he subsequently removed to *Terebratula*. Having found the same species at Whatley, and referred them to *Argyope*, I think it convenient still to retain them in this group, though ultimately it is probable they may have to be separated from it and constituted a subgenus. At present little is known of their loops or internal characters. The Australian examples are more regularly striate than the European Liassic species. Where the striæ on the *A. wollumbillaensis* are occasionally abraded, a canal is visible, which leads me to suspect they were originally hollow, and probably continued in spines beyond the shell, like those on *Athyris* or *Spirifera rostrata*. In its outer form this shell very much resembles some of the *Strophomenidæ*.

7. Argyope punctata, sp. n. Pl. X. fig. 6.

Shell small, transversely ovate; dorsal valve flattened or slightly convex; margins regularly rounded; surface of valve with bifurcating longitudinal striæ, which at the front are thirty in number.

This shell clearly indicates the presence of a second species of this group. Only one valve is known, and this is not perfect. The striæ are much more distant, and stand up in sharp ridges, and the punctations are much coarser and fewer than on the *A. wollumbillaensis*. In these respects the species approaches nearer to the French and English examples.

The specimen is from Wollumbilla, and is attached to the surface of a *Serpula intestinalis*?

8. Discina apicalis, sp. n. Pl. X. fig. 13.

Shell small, round or slightly ovate; apex very acute, almost central, or inclined to anterior end; shell-structure thin, with faint concentric lines of growth.

I have only seen a single, somewhat imperfect, example of this

shell; its chief peculiarity appears to be its very high and conical figure in proportion to its size.

It is from Wollumbilla.

9. Rhynchonella rustica, sp. n. Pl. X. figs. 7–9.

Shell variable, usually wider than long; beak acute; when young, compressed, with both valves slightly convex, without sinus, and margins rounded; with age, the shell is furnished with a broad sinus in the ventral, with a corresponding convexity or mesial fold in the dorsal valve; surface covered with striæ, from 20 to 25 in number, which in the adult shell are somewhat wavy or irregular.

With age the dorsal valve becomes very convex, and the frontal margin considerably thickened. It approaches most closely to the *Rh. concinna* of the Great Oolite and Bradford Clay; but in its general aspect it is a coarser shell, and the plicæ are more irregular. I have seen about twenty examples, so that it must be very abundant. In the hollows of the striæ are occasionally Polyzoa, and attached Foraminifera.

It is from the Wollumbilla district.

10. Rhynchonella solitaria, n. sp. Pl. X. fig. 10.

Shell wider than long; ventral valve with broad mesial sinus, in which are four widely spreading costæ, with a single lateral costa on either side of the sinus. Towards the umbo the shell is smooth, and without appearance of costæ.

Only a single specimen of a ventral valve of this species occurs, in one of the Wollumbilla blocks; and this is not quite perfect.

11. Terebratella Davidsonii, sp. n. Pl. X. figs. 1 & 2.

Shell rather large, transversely ovate or subtrigonal, slightly convex; beak truncated; ventral area extended and slightly depressed below a lengthened, slightly rounded hinge-line. The surface of the valves exhibits distinct but very minute punctations, and possesses wide concentric bands, on which are regular, but much finer, lines of growth; these are crossed by numerous radiating striæ, which, towards the margins of the folds, give the shell a fimbriated appearance, very fine plicæ being visible on the whole of the surface. The larger or dorsal valve possesses a wide mesial fold, with a corresponding sinus on the ventral valve.

Three examples of this very pretty species occur, but only one is free from the matrix and tolerably perfect.

From the Wollumbilla drift-boulders.

12. Avicula Barklyi, sp. n. Pl. XI. figs. 1 & 2.

Shell slightly inequilateral, orbicular; large valve convex, small valve flattened, umbones prominent; auricles rather small, nearly equal.

The large valve is slightly produced posteriorly, and is ornamented by about 24 radiating costæ, which are more raised and appear

spinous on the posterior margin. The small valve is but very slightly convex, and is very distinct in its ornamentation from the larger, the costæ being much finer and about 44 in number. The costæ are decussated by numerous regular concentric lines of growth, which, when they meet, give them a nodulated aspect. The lines of growth have been reflected or folded over the anterior auricle and side, which gives the shell a very peculiar appearance. The small valve possesses a large and deep groove for the passage of a byssus.

The punctate structure of the Aviculidæ may be clearly distinguished, by aid of the lens, in this species. Sections of the shells of this genus are to be seen in almost every block from Wollumbilla; but the above is the only specimen clear of the matrix. It is from Wollumbilla, and is named after Sir Henry Barkly, late Governor of Victoria.

13. Avicula reflecta, sp. n. Pl. XII. fig. 1.

Shell rather inequivalve, rather longer than wide; large valve regularly convex; surface ornamented by about 38 radiating and slightly undulating costæ, every fourth costa being rather more prominent, which are crossed by widely separated interrupted lines of growth. The surface is also decussated by thin bands of concentric striæ, which terminate with a slightly fimbriated or ragged edge.

On the back of this specimen, covering the auricles and the umbo, a small valve is attached, which probably belongs to it. In its general contour it resembles *A. Barklyi*; but the longitudinal costæ are finer and in greater number, being as 57 to 44 in the latter; these are decussated, as on the larger valve, by very thin wavy concentric striæ.

Numerous examples of *Planorbulina Ungeriana* are attached to the small valve; and a *Natica*, with a *Lima* and fragments of other *Aviculidæ*, are in the same block.

Loc. Wollumbilla.

14. Avicula umbonalis, sp. n. Pl. XII. figs. 2 & 3.

Shell thick, transversely ovate; umbo produced and sharply incurved over small valve; hinge-line extended and nearly equal on both anterior and posterior sides; large valve convex, small valve flattened, both of which have longitudinal striæ and narrow wavy lines of growth.

This species is represented by a single specimen, the test of which is imperfect. Its peculiar hinge-line clearly separates it from either of the other Australian species; and its shell, unlike that of the Aviculidæ, is comparatively very thick.

Loc. Wollumbilla.

15. Avicula corbiensis, sp. n. Pl. XI. fig. 7.

Shell longitudinally ovate, longer than wide, nearly equilateral; umbo distinct, raised, curving over hinge-line; posterior auricle short, anterior obsolete; anterior margin and front regularly round-

ing. Surface of the shell with broadish radiating longitudinal striæ, which appear to bifurcate towards the umbo; in the interspaces these are seen to be crossed by fine concentric lines of growth. The shell is slightly produced towards the posterior margin. Small valve not known.

The above species, as well as some other of the Australian forms, appear to be related to the group of which *A. braamburiensis* may be taken as a type.

It was obtained from near Mount Corby.

16. Avicula simplex, sp. n. Pl. XI. fig. 3.

Shell small, very inequilateral; hinge-line straight; posterior auricle very extended, anterior auricle small; left valve convex, thickening at the centre, from which proceed seven or eight radiating costæ; right valve flattened, without costæ. There are also fine concentric lines crossing the shell.

The species is not unlike the young form of *A. costata*; but the posterior auricle is much more produced than in that shell.

Loc. Wollumbilla.

17. Avicula æqualis, sp. n. Pl. XI. fig. 4.

Shell very small, smooth, convex, inequilateral; auricles nearly equal; surface with very faint concentric lines of growth.

Only a single example of the left valve is known. In form it resembles some of the Aviculidæ of the Permian series.

Loc. Wollumbilla.

18. Avicula, sp.

Shell very inequilateral; posterior auricle lengthened, small valve flattened; shell-structure smooth, surface with about 24 fine costæ radiating from the umbo. On the anterior side the shell possesses a large notch for the passage of the byssus. Only a portion of the small valve is known.

Loc. Wollumbilla.

19. Avicula substriata, sp. n. Pl. XI. fig. 6.

Shell small, inequilateral, convex; anterior auricle very small, posterior auricle much extended; anterior margin and front of the shell rounding. The surface has about 13 spreading longitudinal costæ, crossed by faint concentric striæ. The small valve is not exposed.

Loc. Wollumbilla.

20. Lima Gordonii, sp. n. Pl. XII. fig. 4.

Shell ovately oblong, inequilateral, oblique, thin, with about 15-17 rounded costæ, which become obsolete on the posterior side, and with many concentric close-set but distinct lines of growth; hinge-line narrow and straight, posterior side rounded, anterior oblique; ventral margin rounded.

Only one good example of this shell has been sent over; but

there are casts and imperfect examples of the same species which show that it is not uncommon. They are all single valves.

Loc. Wollumbilla. It is named after W. P. Gordon, Esq., of Wollumbilla, through whose assistance many of these fossils have been collected.

21. Lima multistriata, sp. n. Pl. XII. fig. 5.

Shell very convex, oblique; auricles very small; hinge-border very narrow; surface with about forty depressed rounded costæ, with narrow interstitial spaces.

The surface of this shell is somewhat abraded, and its frontal margin is incomplete. It is very convex or inflated towards the umbones. Only one specimen is known, which is from Wollumbilla.

22. Pecten (?) æquilineatus, sp. n. Pl. XI. fig. 11.

Shell ovately orbicular, moderately convex; surface covered with numerous raised divergent longitudinal striæ, crossed by about the same number of equally raised concentric costæ, which narrow towards the apex, where, decussating the longitudinal striæ, they present small folds or punctate-looking bosses; interstitial spaces smooth, auricles large, unequal.

This shell approaches nearest in ornamentation to the *P. retiferus* of the Great Oolite, but it has a much larger number of concentric costæ and is much more delicately marked than that shell.

Only one perfect example is known; but fragments of several others show that it is not an uncommon shell.

Loc. Wollumbilla.

23. Pecten socialis, sp. n. Pl. XI. fig. 9.

Shell suborbicular, moderately convex; umbones convex and pointed, auricles large, unequal, anterior one much the largest.

The external ornamentation of this shell is not well preserved; but it appears to have been nearly smooth, without visible concentric striæ, but with depressed radiating ribs. In general form it is not unlike *P. rigidus*. It is one of the most abundant shells in the boulders from Wollumbilla, many specimens of all ages appearing on their fractured surfaces.

Loc. Wollumbilla.

24. Pecten greenoughiensis, sp. n. Pl. XI. fig. 10.

Shell small, ovately orbicular, auricles oblique, narrow, unequal; surface with very numerous, close, slightly waving costæ, about forty-eight in number, which are crossed by very fine regular concentric striæ, which give the shell an ornate aspect.

From the Greenough district, Western Australia.

25. Pecten fimbriatus, sp. n. Pl. XI. fig. 8.

Shell rather convex, with numerous longitudinal slightly nodulated costæ at the front of the shell, and continuing to about the middle, where they die out, are faint intermediate striæ. These are

crossed by regular concentric fimbriated striæ, which in the interspaces are produced beyond the shell. The umbo and auricles are wanting, and the shell is otherwise imperfect.

Loc. Wollumbilla.

26. PERNA GIGANTEA, sp. n.

Shell very large, measuring $6\frac{1}{4}$ inches broad by $5\frac{1}{2}$ inches in length, inequilateral, flattened; umbones depressed and rather produced; anterior byssal area rounded, hinge-line rather oblique, extending one-third the width of the shell; posterior end oblique, rounded and folding towards the ventral margin, which with the anterior end is rounded.

It is in a sandy boulder somewhat resembling green sand, which under the lens is seen to contain black-looking chloritic grains. The boulder contains *Lingula ovalis* and *Mytilus*, which show the *Perna* to be of the same age as the Wollumbilla series.

It is the only example known, and is from Wollumbilla.

27. ARCA PLICATA, sp. n. Pl. XII. fig. 6.

Shell small, quadrate, left valve convex; hinge-area wing-like and extended, angular; posterior margin truncated; surface with a few wide radiating striæ, several of the more distinct of which are on the angulated portion of the posterior end.

Only one example is known. It is from Wollumbilla, and the block also contains many *Lingulæ* and small Pectens.

28. ARCA PRÆLONGA, sp. n. Pl. XIV. fig. 7.

Shell transverse, inequilateral; umbones rather close, anterior; hinge-line long, with numerous close-set teeth; posterior side extended and slightly angulated, with a depressed keel crossing from the umbo to the posterior ventral margin. The specimen does not exhibit the finer ornamentation of the test.

It is from Wollumbilla.

29. ASTARTE APICALIS, sp. n. Pl. XIII. fig. 11.

Shell small, trigonal, flattened; umbones very acute, almost mesial; anterior and posterior margins oblique; ventral margin straight; surface ornamented with distant raised and straight transverse lines of growth.

Several specimens of this species are attached to one of the blocks from Western Australia. It is associated with *Trigonia Moorei*, Lyc., *Cucullæa*, &c., and is evidently to be referred to the Inferior Oolite.

Loc. The Greenough district.

30. ASTARTE CLIFTONI, sp. n. Pl. XIII. fig. 10.

Shell thick, ovately trigonal, flattened, inequilateral; umbones acute, small, anterior; anterior side short; posterior end the longest, very oblique, and produced towards the ventral margin, which is

rounded; lunule rather large, oval; concentric striæ very numerous and regular.

This shell approaches *A. subtrigona*, Münst., but is too oblique for that shell, and possesses much more regular striations.

From the Greenough river, Western Australia.

31. Astarte wollumbillaensis, sp. n. Pl. XII. fig. 12.

Shell small, thick, ovately orbicular, gibbous; umbones large, mesial; posterior side rather extended; anterior slightly oblique; ventral margin rounded; shell covered with numerous regular concentric rugæ, with deepish interspaces, and with three or four interrupted folds of growth.

Loc. Wollumbilla.

32. Cucullæa inflata, sp. n. Pl. XIV. figs. 1 & 2.

Shell very gibbous and inflated, longer than broad; umbones mesial, much raised, separate, and projecting over a hinge-line which is shorter than the greatest breadth of the valves; dorsal margin rounded; posterior and anterior ends much truncated, the former with an obtuse carina, which crosses from the umbo to the dorsal margin, towards which the shell is much angulated; surface covered by numerous regular concentric striæ, which are crossed by faint costæ most distinct on the anterior side.

The peculiarly gibbous and truncated form of this shell readily distinguishes it from all the other species of this genus. In its greatest width it does not exceed $2\frac{1}{4}$ inches, whilst, measuring from the umbo to the dorsal margin, it is $3\frac{1}{4}$ inches long, the diameter of the valves being about $2\frac{3}{4}$ inches.

It is from the Greenough district.

33. Cucullæa semistriata, sp. n. Pl. XIV. fig. 3.

Shell transversely oblong; umbones anterior, rather depressed; hinge-area bounded by a lanceolate striated space; posterior end lengthened, attenuated, and angulated, with an obtuse oblique carina; anterior end rather short and rounded; surface covered by very fine concentric striæ.

This shell in its general form approaches *C. oblonga*, with which it is found; but it has a much finer ornamentation, and the radiating decussating striæ appear nearly obsolete, and can only be detected by aid of the lens.

From the Greenough district.

34. Cucullæa, sp.

A third species is found with the above, to be distinguished by its being much narrower or transversely elongated; but neither of two examples are sufficiently perfect for description. *C. oblonga* is the most frequent of this genus; so that four species occur in the Oolite of Western Australia.

35. Cytherea Clarkei, sp. n. Pl. XIII. fig. 1.

Shell large, thick, rather compressed, transversely ovate, inequi-

lateral, moderately convex; umbones flattened, incurved over a large and rounded lunule; anterior and posterior ends and dorsal margin rounded; surface of the shell with broad irregular transverse bands of growth.

Fine examples of this shell are present in the Rev. W. B. Clarke's collection. It is one of the largest of the Australian bivalves, and appears to have attained a large size even for a *Cytherea*. The specimens are not in good condition. The largest example measures $6\frac{1}{4}$ inches in breadth by $4\frac{1}{4}$ inches in depth. The interior of one of the specimens was covered by Polyzoa and *Serpulæ*, the casts of which are still seen in the matrix.

Locs. One example is from the Maranoa river, others being from Wollumbilla and one from the Gregory, north of Finnis Springs, on Stuart's route from Adelaide to Chambers Bay.

36. Cytherea gibbosa, sp. n.

A second species, much more convex and gibbous, with umbones much thickened, is present, but the specimen is too imperfect for description. It is from Wollumbilla.

37. Goniomya depressa, sp. n. Pl. XIII. fig. 6.

Shell ovately elongated, thin, flattened; umbones close, depressed, mesial; anterior end rounded; the middle of the valves with a depression or fold from the umbo, which widens to the ventral margin, surface with broad curved rounded costæ.

A single specimen, which has lost a part of the posterior end, represents this genus. The test is not well preserved, so that the entire ornamentation cannot be determined.

It is from Wollumbilla.

38. Leda australis, sp. n. Pl. XII. fig. 7.

Shell transversely ovate; umbones anterior, contiguous, compressed; anterior side rounded, posterior side longest, attenuated; hinge-teeth small, numerous; dorsal surface covered with numerous transverse striæ.

Loc. Wollumbilla.

39. Lucina anomala, sp. n. Pl. XIV. fig. 4.

Shell nacreous, thin, equivalve, suborbicular, compressed; umbones mesial, close; lunule small, distinct; hinge-line much extended, on the posterior side rounded, on the anterior oblique and wing-like.

The surface of the shell possesses very close radiating longitudinal striæ, decussated by equally close concentric striæ which give the shell a faintly reticulated appearance. The longitudinal striæ are more distinctly marked than is usual with the *Lucinidæ*.

Loc. Wollumbilla.

40. Lucina (?) australis, sp. n. Pl. XIV. fig. 5.

Shell orbicular, or longitudinally ovate, nacreous; umbones mesial,

depressed; valves slightly convex; hinge-line on anterior side extended and rather rounded; margin of the valves regularly rounded; surface ornamented by very close but distinct longitudinal costæ.

This shell may be distinguished from the *L. anomala* by the costæ being finer; and although it is larger, the anterior hinge-line is less extended. Its surface, under the lens, presents a wrinkled appearance, probably indicating the presence of fine concentric lines of growth which have been obliterated. It exhibits broad concentric bands.

Loc. Wollumbilla.

41. Mactra trigonalis, sp. n. Pl. XIV. fig. 6.

Shell small, thin, trigonal; umbones rather anterior; anterior end rounded and rather angular; front margin rounded; the surface is marked by faint transverse lines.

A thin slab from the Downs on the Nive river, appears to be almost composed of this little shell. One species of the genus is recorded by Professor M'Coy from Carboniferous strata, and another is described from the Greensand; otherwise the genus is chiefly met with in Tertiary deposits.

42. Mytilus rugo-costatus, sp. n. Pl. XIII. fig. 2.

Shell thick, ovately oblong; umbones terminal and acute; posterior margin oblique and curved; anterior side produced and somewhat rounded; the dorsal surface is obtusely keeled, and towards the umbo has very coarse irregular concentric striæ or lines of growth, which become finer towards the ventral margin.

Unlike the *Mytilidæ* generally, whose shells are usually thin and fragile, this species possesses a very thick test, especially in the adult examples. When a portion of the test has adhered to the matrix, leaving an inner layer exposed on the shell, the striæ are not seen, and the surface appears smooth, giving it the appearance of an entirely different species.

It is from Wollumbilla, and appears to be frequent.

43. Mytilus planus, sp. n. Pl. XIII. fig. 3.

Shell small, thin, ovate, compressed, nearly equilateral; umbones terminal and acute, ventral margin rounded; dorsal surface smooth, with depressed concentric lines of growth, crossed by very fine radiating lines, which wholly cover the exterior. Its flattened form, with its distinct ornamentation, readily distinguishes the species.

I have only seen one specimen, which is from Wollumbilla.

44. Mytilus inflatus, sp. n. Pl. XIII. fig. 4.

Shell smooth, slightly inequivalve, convex, both valves inflated; margins close-set; umbones terminal, acute, anterior; hinge-line extended and oblique; posterior margin and front rounded; dorsal surface smooth, with irregular concentric bands of growth.

This pretty little shell is to be distinguished by its very inflated appearance, its more extended hinge-line, and terminal umbones. Its test still retains some colour.

Two examples are in the Australian collection, both of which are from Wollumbilla.

45. Modiola unica, sp. n. Pl. XIII. fig. 5.

Shell small, smooth, obtuse, convex, thickest at the umbones; umbones subterminal; hinge-line straight; anterior side produced and rounded; dorsal surface with a few flattened concentric striæ, which are decussated by very faint longitudinal lines. This little inflated shell is the only example I have seen of the genus.

It is from Wollumbilla.

46. Mya Maccoyi, sp. n. Pl. XIII. fig. 8.

Shell ovately oblong, moderately large, tumid, inequivalve; umbones anterior, incurved, close; anterior margin truncated, angular; posterior end attenuated, rounded, widely gaping; ventral margin slightly rounded; surface of the shell with wide irregular lines of growth, the outer surface of the test where best preserved showing it to be very wrinkled. It is $3\frac{1}{4}$ inches broad by $2\frac{1}{4}$ in height.

I have only seen one specimen of this species, which has come from a deposit of dark blue limestone. It comes from between the Amby and Maranoa rivers. It is named after Professor M'Coy, who has been for some time engaged in the geological survey of Victoria.

47. Panopæa rugosa, sp. n. Pl. XIII. fig. 7.

Shell transverse, ovate, inequilateral, inflated, thickest and broadest on the anterior side; umbones acute; hinge-line prominent, with a raised ridge for ligamental attachment; anterior margin rounded and slightly gaping; from the umbo on the upper dorsal margin to the posterior side gradually gaping; surface of the shell with irregular concentric lines, with an external wrinkled shell-structure.

Only one example of this shell is in the collection. It measures $4\frac{1}{2}$ inches in breadth by $2\frac{1}{2}$ inches in height.

It comes from the Bungeeworgorai Creek, twenty miles south-east from Mount Abundance.

From the parasitic attachments on the interiors of many of the Australian specimens, they appear to have been *dead* shells. Two examples of casts produced by the attachment of Cirripedia are to be seen on the interior of this *Panopæa*.

48. Myacites Sanfordii, sp. n. Pl. XIII. fig. 9.

Shell elongate, flattened; umbones rather anterior, close; anterior side slightly produced and rounded, posterior side lengthened and attenuated; front dorsal margin slightly curving, with the edges of the valves close; both ends slightly gaping.

This shell approaches very closely to *M. calceiformis* of the Inferior Oolite.

Several specimens of this shell are in the Western Australian collection. It appears to be from the Inferior Oolite. It is named after W. A. Sanford, Esq., F.G.S., to whom I am indebted for the Western-Australian specimens.

49. Myacites planus, sp. n. Pl. XII. fig. 10.

Shell thin, ovately elongated; umbones rather anterior, depressed, close; anterior margin attenuated; posterior side most convex, with an obtuse slope to a moderately rounded margin; inferior margin rounded; the dorsal surface possesses transverse interrupted lines of growth, with, in the interspaces, numerous fine concentric striæ.

From Wollumbilla; only one example is known.

50. Nucula Cooperi, sp. n. Pl. XII. fig. 8.

Shell trigonal, very convex; umbones rather anterior, widely separated; anterior side angular, posterior side rather produced and attenuated; ventral margin rounded.

This shell, for a *Nucula*, attains considerable size. It is named after Sir Daniel Cooper, Bart., late Speaker of the Sydney House of Assembly.

It is from Wollumbilla.

51. Nucula truncata, sp. n. Pl. XII. fig. 9.

Shell triangular; umbones anterior, compressed; anterior side very truncated; dorsal margin rounded; hinge-line with about seven large teeth on the posterior side of the umbo, and with four or five on the anterior side.

Only a single specimen of this shell occurs. It is readily distinguished from *N. Cooperi* by its more compressed form and truncated margin.

Loc. Wollumbilla.

52. Thracia Wilsoni, sp. n. Pl. XIV. fig. 8.

Shell thin, transversely ovate, slightly inequivalve, compressed; umbones obtuse, anterior; anterior side short and roundly truncated, posterior side rounded and angular; ligament external, anterior to the umbones; dorsal surface covered with very fine irregular wavy lines of growth, which become oblique on the posterior margin.

The right valve possesses a slight sinus towards the centre of the ventral margin, with a corresponding elevation on the opposite valve. Two specimens of this shell have been found. Breadth 3 inches, height $2\frac{1}{2}$ inches.

One is from the Amby river, the other from the Bungeeworgorai creek. It is named after J. R. Wilson, Esq., of Bungeeworgorai.

53. Tancredia plana, sp. n. Pl. XIII. fig. 13.

Shell thin, smooth, flattened, transversely ovate, rather inequivalve; anterior side rounded: posterior margin oblique; surface of the shell covered by very fine transverse striations.

The matrix contains portions of *Avicula* &c.

Only one example is known. It is from Blythesdale, fifteen miles from Wollumbilla.

54. Trigonia Moorei, Lycett, sp. n.. Pl. XIV. figs. 9 & 10.

[Allied to *T. costata*, but has the general figure more ovate and

depressed; the umbones are more mesial, less recurved and less prominent; the area is larger, its proportions being as 1 to $1\frac{1}{2}$ compared with the costated portion of the shell; in *T. costata* it is as 1 to $2\frac{1}{2}$; the area is not concave, but has a median groove replacing the usual median carina, and there is scarcely any inner carina; the marginal carina is very large and broad, but not much elevated, with regular large transverse lamellæ; anterior to the carina is a well-marked smooth, depressed, oblique sulcus; the costæ are numerous, short, simply and concentrically curved, rising upwards to meet the anterior border at a considerable angle; in *T. costata* the costæ meet the border horizontally with a slight undulation; in the advanced stage of growth the costæ are continued postically across the carina and area, forming a slight undulation as they cross the depressed postero-costal furrow. These several characters will in the aggregate serve sufficiently to distinguish it from all the known European forms of the costated *Trigoniæ*.—J. L.]

55. Trigonia lineata, sp. n. Pl. XIII. fig. 12. *Myophoria*, M'Coy.

Shell thick, equivalve, inequilateral, gibbous, as broad as long; umbones convex, recurved towards the anterior margin; anterior side and ventral margin rounded; posterior angle somewhat rounded; marginal carinæ absent; shell gradually sloping to the front; surface with close-set regular transverse concentric striæ, about twenty in number, which on the anterior margin possess depressed tubercles.

Two specimens of this shell have been sent over—the one a cast showing the teeth, the other with the test much abraded and therefore exhibiting probably but imperfectly the surface characters that might be present on better examples.

The contour and the ornamentation of this shell remind us of *T. gibbosa* of the Portland Oolite, but it is more generally rounded and gibbous than that species.

Professor M'Coy, in his catalogue of the Australian Mesozoic species, places it under *Myophoria*; but it does not possess the oblique keel and the acute posterior side of that Permian and Rhætic genus, which, moreover, never attains the size of this shell.

From the Wollumbilla deposit.

56. Teredo australis, sp. n. Pl. XII. fig. 11.

Shell small, convex, rather quadrate; umbones mesial; surface with a curved furrow proceeding from the umbo to the centre of the ventral margin, and with numerous transverse striæ, which pass obliquely into the mesial furrow, especially from the anterior side; anterior end with six or seven faint, close longitudinal striæ, which, decussating the transverse lines, give it a wavy look; anterior margin reflected and gaping.

A numerous colony of these shells was attached to a piece of fossil wood, the impression only of which is left in the stone. They occur in the block with *Cucullææ*, *Trigoniæ*, &c. of Oolitic age, from Western Australia.

57. Actæon Hochstetteri, sp. n. Pl. X. fig. 19.

Shell rather small, ovate; whorls five; spire rather elevated, acute; whorls covered by close, distinct, encircling transverse striæ, about thirty in number on the body-whorl, which is rather convex; aperture not exposed.

In general appearance this shell is not unlike *A. pullus*, Lycett, but the striæ with which it is ornamented are much more numerous. It is from Wollumbilla. It is named after Dr. F. von Hochstetter, who has published a valuable work on the geology of New Zealand.

Only one specimen is known.

58. Actæon depressus, sp. n. Pl. X. fig. 20.

Shell small, conical; spire with five volutions, rather depressed; body-whorl with about fifteen rather distant striæ; aperture ovate.

Although this shell is not in good condition, it is clearly separable from *A. Hochstetteri* by its more depressed figure, and by the difference in the external striæ. I have only seen one example, which is also from Wollumbilla.

59. Cerithium greenoughiensis, sp. n. Pl. X. fig. 22.

Shell small, narrow, tapering; apex acute; volutions 7–8, separated by a narrow encircling suture, and ornamented with short, straight longitudinal costæ, bounding which are a row of nodulations.

In the block with *Trigonia Moorei* &c., from the Greenough district, Western Australia.

60. Delphinula reflecta, sp. n. Pl. X. fig. 21.

Shell rather small, turbinated; whorls 3–4; spire slightly elevated; volutions separated by an encircling sinus; body-whorl much increased; aperture circular, with a thick reflected lip.

Only one specimen is known, the test of which is not in good condition. It is from Wollumbilla.

61. Dentalium lineatum, sp. n.

Shell tubular, rather thin, tapering and slightly curved.

Three specimens occur with the Queensland series, all of which are from Wollumbilla.

62. Natica variabilis, sp. n. Pl. X. fig. 15.

Shell very thick, broader than high; spire of 3–4 volutions, somewhat depressed; body-whorl increasing rapidly in size and extended; aperture ovate; umbilicus small.

This species is abundant, and I have had an opportunity of examining specimens in various conditions. When the body of the shell has been worn, it presents a rugosely striated surface; but in smaller examples, in which the shell is usually better preserved, the test is seen to have a comparatively smooth striated exterior.

Loc. Wollumbilla.

63. Natica ornatissima, sp. n. Pl. X. fig. 16.

Shell small; spire depressed; whorls convex, the last very rounded and globose; aperture large and circular.

Shell-structure smooth, with broad bands of growth at intervals, within or on the surface of which are finer striations. The shell still retains some of its original colour.

One specimen only, from Wollumbilla.

64. Rissoina australis, sp. n. Pl. X. fig. 23.

Shell very small, moderately elevated; spire consisting of five rounded or convex volutions, with distinct rounded sutures, which are ornamented with numerous longitudinal costæ.

This shell, which is very minute, is from Western Australia. Only one specimen has been recognized.

65. Turbo australis, sp. n. Pl. X. figs. 17 & 18.

Shell small, discoidal; spire obtuse and much depressed; whorls 4, the outer circumference convex; surface with slightly curved, depressed lines of growth; mouth large, ovate.

This shell is from Western Australia.

66. Crioceras australe, sp. n. Pl. XV. fig. 3.

Shell very large, discoidal; whorls rounded, incurved, the inner whorls rather closely fitting but separate. In the younger state, as seen in the reduced figure, the shell possesses regular rounded slightly curved ribs with intervening rounded sulci, which increase in width with the age of the shell. In the adult shell the ribs become widely separated, the largest chamber measuring at the back $3\frac{1}{2}$ inches, and they possess very acute ridges, with two depressed bosses on either side, the depressions between the ribs being regularly concave.

The block containing the last five chambers of the shell is slightly compressed on the back; and, though it is not complete, the mouth measures $7\frac{1}{2}$ inches in depth by 7 inches in breadth. The siphuncular tube is small and situated immediately under the back of the shell.

There appears no reason to doubt that the larger chambers belong to the smaller whorls, though the connecting portions are wanting. When complete, it is probable the shell attained nearly twice the dimensions of the *C. Bowerbankii* of the Lower Greensand. Its ornamentation is proportionally much coarser than in that species.

On the interior of the shell are attached Polyzoa, *Serpulæ*, and other remains identical with those on the interior of the *Cytherea Clarkei* previously noticed, from which there appears no doubt that that shell and the *Crioceras* are identical in age; and as no example of *Crioceras* has yet been obtained out of the Neocomian period, it is reasonable to infer that they represent it on the Australian continent.

It is from the district of the Upper Maranoa.

? TEUTHIS. Pl. XVI. fig. 8.

Small portions of the shaft of a *pen* with the lateral expansion of the wings indicate the presence of a Cephalopod allied to the Calamaries. The remains I have noticed are all very fragmentary, the largest being figured as above. They are from Wollumbilla.

AUSTRALIAN BELEMNITES.

Note by Prof. John Phillips.

Of three species which are in the Australian collection sent me by Mr. C. Moore, the first, a large *phragmocone* typical of the Oolitic system (meaning by this the whole series of beds from the Middle Lias to the Kimmeridge Clay inclusive) is 5·5 inches long, its greatest diameter 1·75, the section nearly circular. Above forty septa can be counted; and the whole number must have been fifty, without reaching the last chamber. The septa are a little oblique, advancing in the dorsal and retiring a little on the ventral face, with a slight lateral flexure. Depth of the chambers about one-sixth of the diameter. Siphuncle clearly internal, its section rather elliptical. The phragmocone is nearly straight, with an angle of 18°.

Of the *guard* only a slight indication of a subcentral axis can be recorded. I cannot at present assign its distinctive characters. Wollumbilla.

The second species occurs in Queensland, and is represented by several frusta of the guard, but no phragmocone. It is not identical with any European or Indian form known to me.

67. BELEMNITES AUSTRALIS, sp. n. Pl. XVI. figs. 1–5.

Guard hastate, depressed in the postalveolar region by lateral expansion; ventral face somewhat flattened, but without trace of a ventral groove; two lateral grooves sharply cut, and approximating to the ventral face in the alveolar region, thence bending toward the dorsal aspect, and continued in a fine stria on the middle of the side (figs. 1, 2).

Length $4\frac{1}{2}$ inches to the point where the guard grows thin over the phragmocone; diameters at the alveolar apex 0·725 and 0·600, further back in the more flattened part 0·770 and 0·600. Axis of the guard 3·300.

Proportion of axis to ventro-dorsal diameter as 550 to 100, of ventral to dorsal radius 40 to 60.

Phragmocone unknown. Its angle 20°. A younger specimen, marked "Ward, C. K.," is more distinctly hastate, and shows the flexure of the lateral groove more clearly than the others from "Queensland." Figs. 3, 4.

A much older specimen, also marked "Ward, C. K.," is a split half, the fissure being dorso-ventral. It shows the lateral groove, marked with a double stria, and the nearly straight-sided excentric alveolus. The axis of the guard is curved, and channelled, as in some specimens from the Oxford Oolite. The ventral portion is to the dorsal as 40 to 60; the axis, as is usual in old specimens of hastate

Belemnites, is not longer than in youth, and its proportion to the diameter is reduced to 240 : 100.

These fossils appear on the whole most allied to *Belemnites hastatus* of Blainville, and to the depressed variety of it which occurs in the Oxford Clay of England. But they are entirely distinct by the lateral grooves being so sharply cut over the alveolar and postalveolar region, and by the absence of ventral groove.

There is, indeed, one specimen (the posterior part of a large guard) marked Upper Maranoa river, which, with portions of the lateral grooves, shows along the ventral face a partially impressed but interrupted groove, not unlike some appearances on *Belemnites sulcatus* of the Oxford Clay of England. The lateral grooves show ramifications, and appear not to bend backward. It may be a different but allied species.

Finally there is a small nearly cylindrical Belemnite, with a subcentral axis and an acute-angled alveolar cavity. It has one long narrow groove, not clearly seen to be a ventral groove. Though incompletely exhibited, it must be a distinct species from the others. It is marked Upper Maranoa. It is not one of the *Canaliculati*, but more probably one of the *Hastati*.—J. P.

Since the above notes were made by Professor Phillips, I have succeeded in opening up two imperfectly exhibited specimens in a block from Wollumbilla (Pl. XVI. fig. 6), respecting which he remarks "that they belong to young Belemnites and show the phragmocone *in situ*, and the straight nearly central axis of the guard, with a small canal. The cross section of the phragmocone is distinctly elliptical and oblong; the siphuncle is clearly enclosed; longitudinal dorsal striæ very distinct. I have made a sketch of these points, which on the whole make me adhere to the opinion of the Oolitic, and perhaps Liassic, affinity of this shell. It appears to be most nearly allied to *B. paxillosus*, but to be distinct by its elliptical phragmocone: this ellipticity diminishes with age."

DESCRIPTION OF PLATES X.–XVIII.

(All the figures are of the natural size, except where stated to be otherwise.)

Plate X.

Fig. 1. *Terebratella Davidsonii*, Moore, dorsal valve.
2. The same, ventral valve.
3. *Argyope wollumbillaensis*, Moore, dorsal valve, enlarged one-half.
4. The same, ventral valve, enlarged one-half.
5. The same, interior of dorsal valve.
6. *A. punctata*, Moore, dorsal valve, enlarged.
7. *Rhynchonella rustica*, Moore, dorsal valve.
8. The same.
9. The same, ventral valve, younger specimen.
10. *R. solitaria*, Moore, ventral valve.
11. *R. variabilis*, Schloth., dorsal valve, rather enlarged.
12. The same, ventral valve, rather enlarged.
13. *Discina apicalis*, Moore, enlarged.
14. *Lingula ovalis*, Sow.
15. *Natica variabilis*, Moore.

16. *Natica ornatissima*, Moore.
17. *Turbo australis*, Moore, front view, enlarged.
18. The same, back view, enlarged.
19. *Actæon Hochstetteri*, Moore, rather enlarged.
20. *A. depressus*, Moore, rather enlarged.
21. *Delphinula reflecta*, Moore, enlarged.
22. *Cerithium greenoughiensis*, Moore, enlarged.
23. *Rissoina australis*, Moore, enlarged.

PLATE XI.

Fig. 1. *Avicula Barklyi*, Moore, right valve.
2. The same, left valve.
3. *A. simplex*, Moore, enlarged.
4. *A. æqualis*, Moore, enlarged.
5. *A. braamburiensis*, Phil., rather enlarged.
6. *A. substriata*, Moore, enlarged.
7. *A. corbiensis*, Moore.
8. *Pecten fimbriatus*, Moore.
9. *P. socialis*, Moore.
10. *P. greenoughiensis*, Moore, enlarged.
11. *P.* (?) *æquilineatus*, Moore.

PLATE XII.

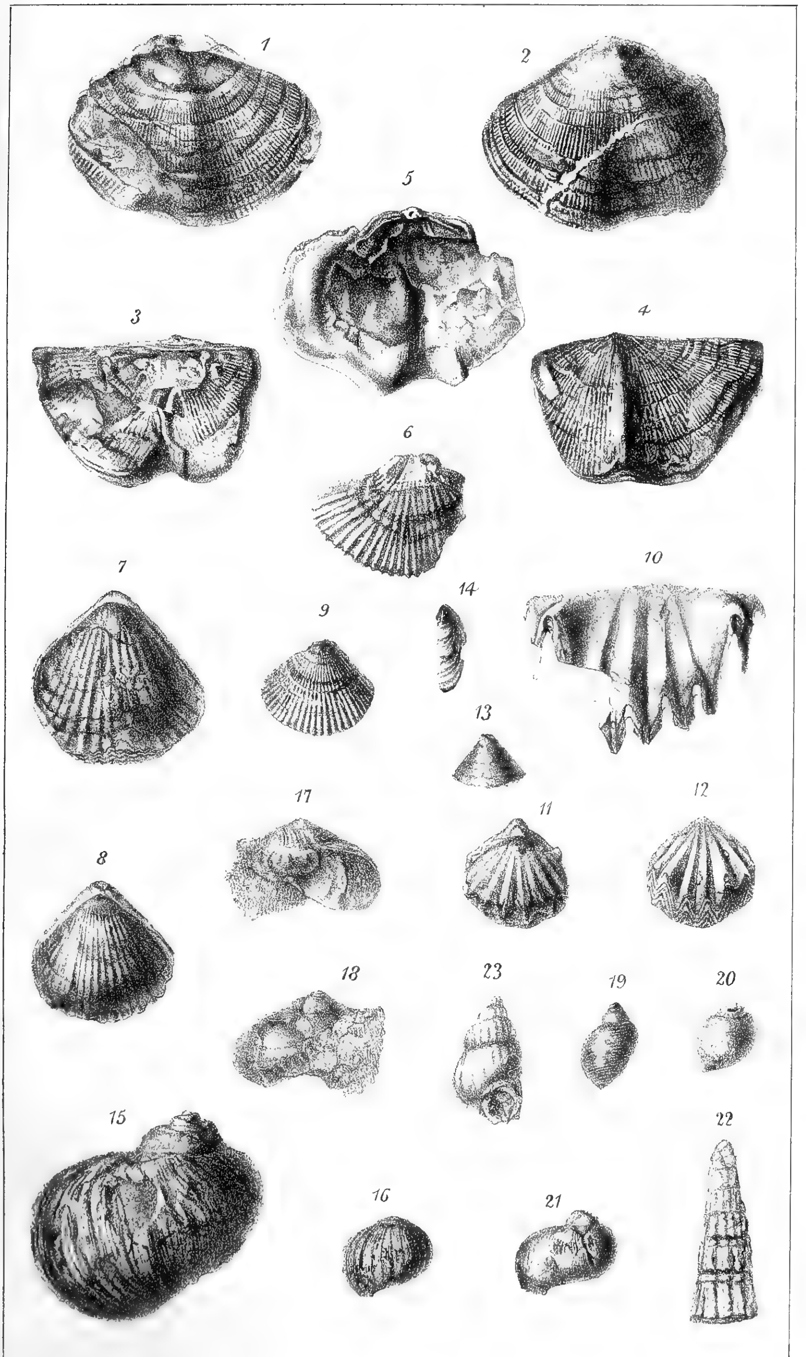
Fig. 1. *Avicula reflecta*, Moore, reduced one-half: *a*, right valve; *b*, left valve.
2. *A. umbonalis*, Moore, left valve.
3. The same, right valve.
4. *Lima Gordonii*, Moore.
5. *L. multistriata*, Moore.
6. *Arca plicata*, Moore, enlarged.
7. *Leda australis*, Moore, enlarged.
8. *Nucula Cooperi*, Moore.
9. *N. truncata*, Moore.
10. *Myacites planus*, Moore.
11. *Teredo australis*, Moore, enlarged.
12. *Astarte wollumbillaensis*, Moore, enlarged.

PLATE XIII.

Fig. 1. *Cytherea Clarkei*, Moore, reduced to one-fourth.
2. *Mytilus rugo-costatus*, Moore.
3. *M. planus*, Moore.
4. *M. inflatus*, Moore.
5. *Modiola unica*, Moore, enlarged.
6. *Goniomya depressa*, Moore.
7. *Panopæa rugosa*, Moore, reduced one-half.
8. *Mya Maccoyi*, Moore, reduced one-half.
9. *Myacites Sanfordii*, Moore, reduced one-half.
10. *Astarte Cliftoni*, Moore, enlarged.
11. *A. apicalis*, Moore, enlarged.
12. *Trigonia lineata*, Moore.
13. *Tancredia plana*, Moore.

PLATE XIV.

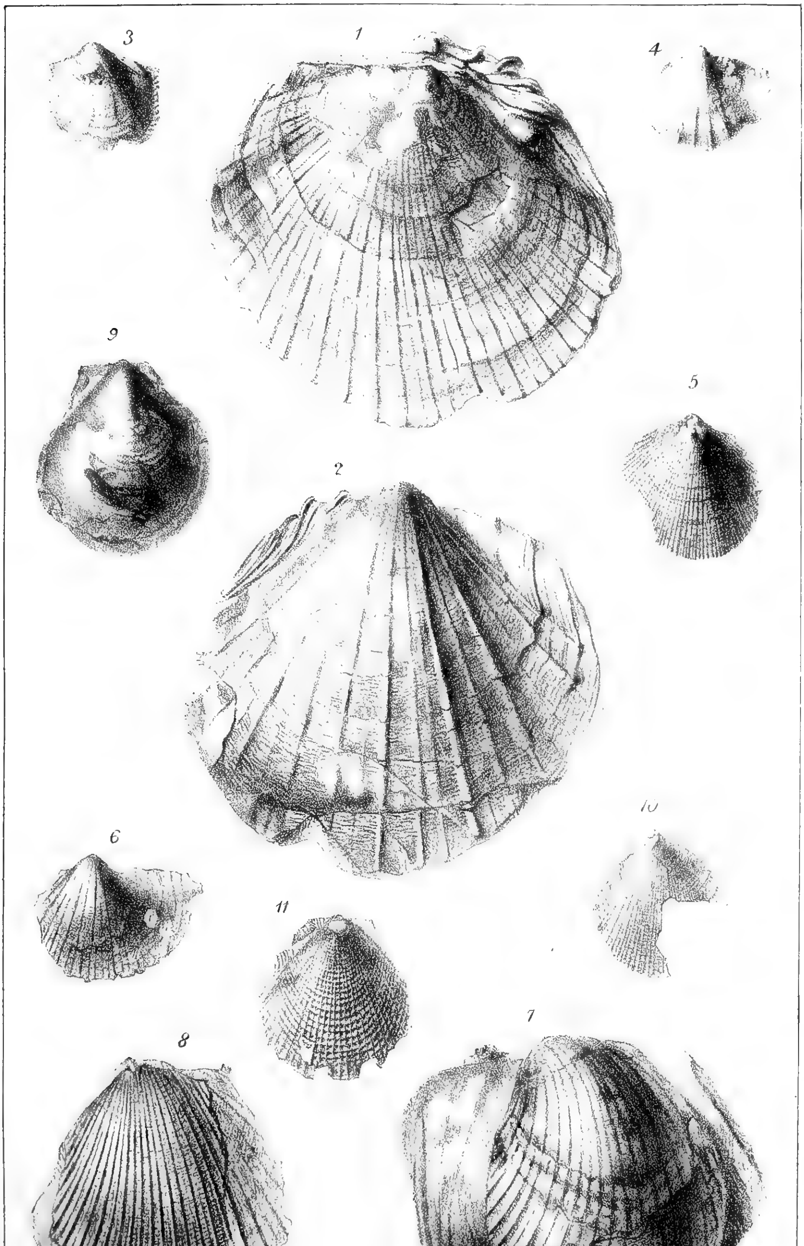
Fig. 1. *Cucullæa inflata*, Moore, reduced one-half.
2. The same, showing hinge-line.
3. *C. semistriata*, Moore, reduced one-half.
4. *Lucina* (?) *anomala*, Moore.
5. *L.* (?) *australis*, Moore.
6. *Mactra trigonalis*, Moore, enlarged.
7. *Arca prælonga*, Moore, enlarged.
8. *Thracia Wilsoni*, Moore, reduced one-half.
9. *Trigonia Moorei*, Lycett, left valve, reduced one-half.
10. The same, right valve, nat. size.



Hollick lith.

M.& N. Hanhart imp.

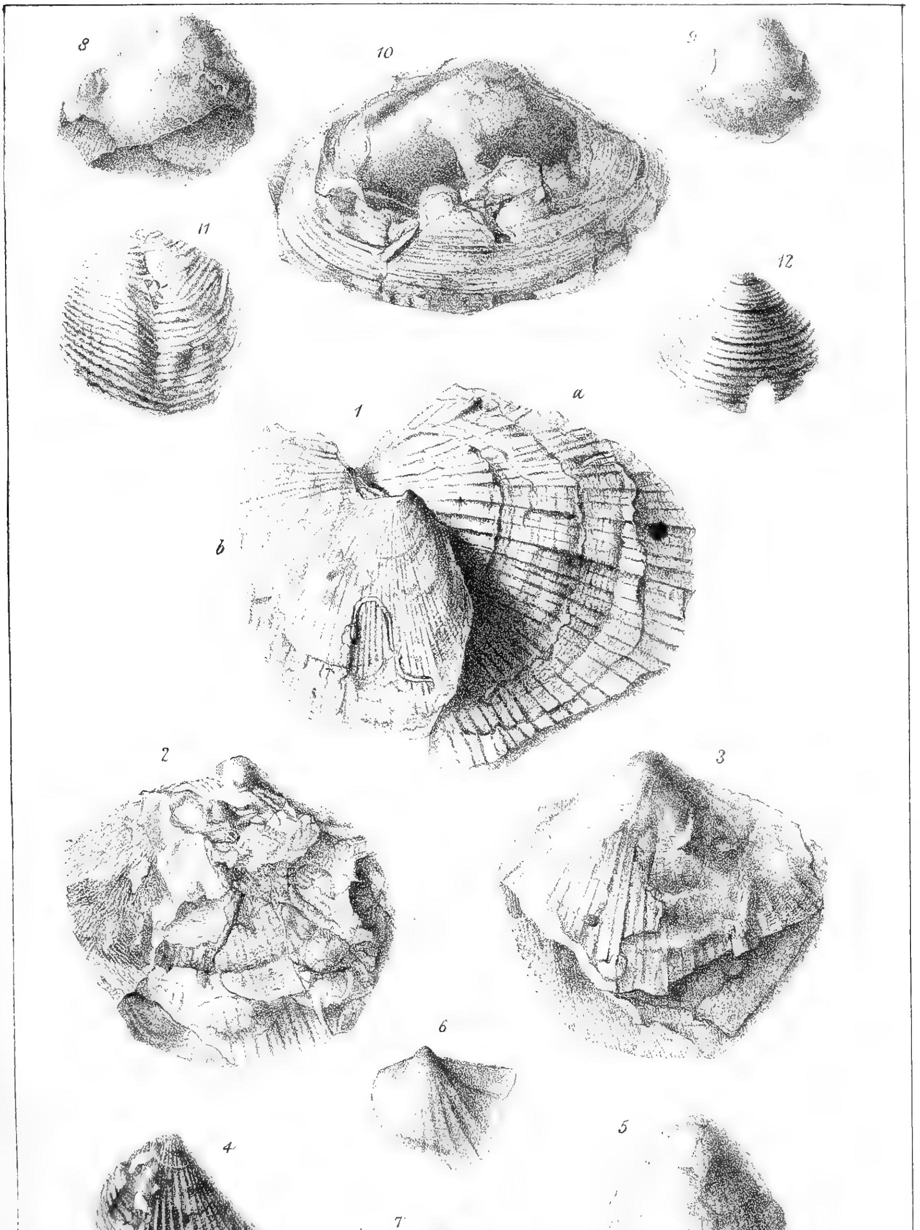
AUSTRALIAN MESOZOIC FOSSILS.



Hollick, lith.

M & N. Hanhart imp

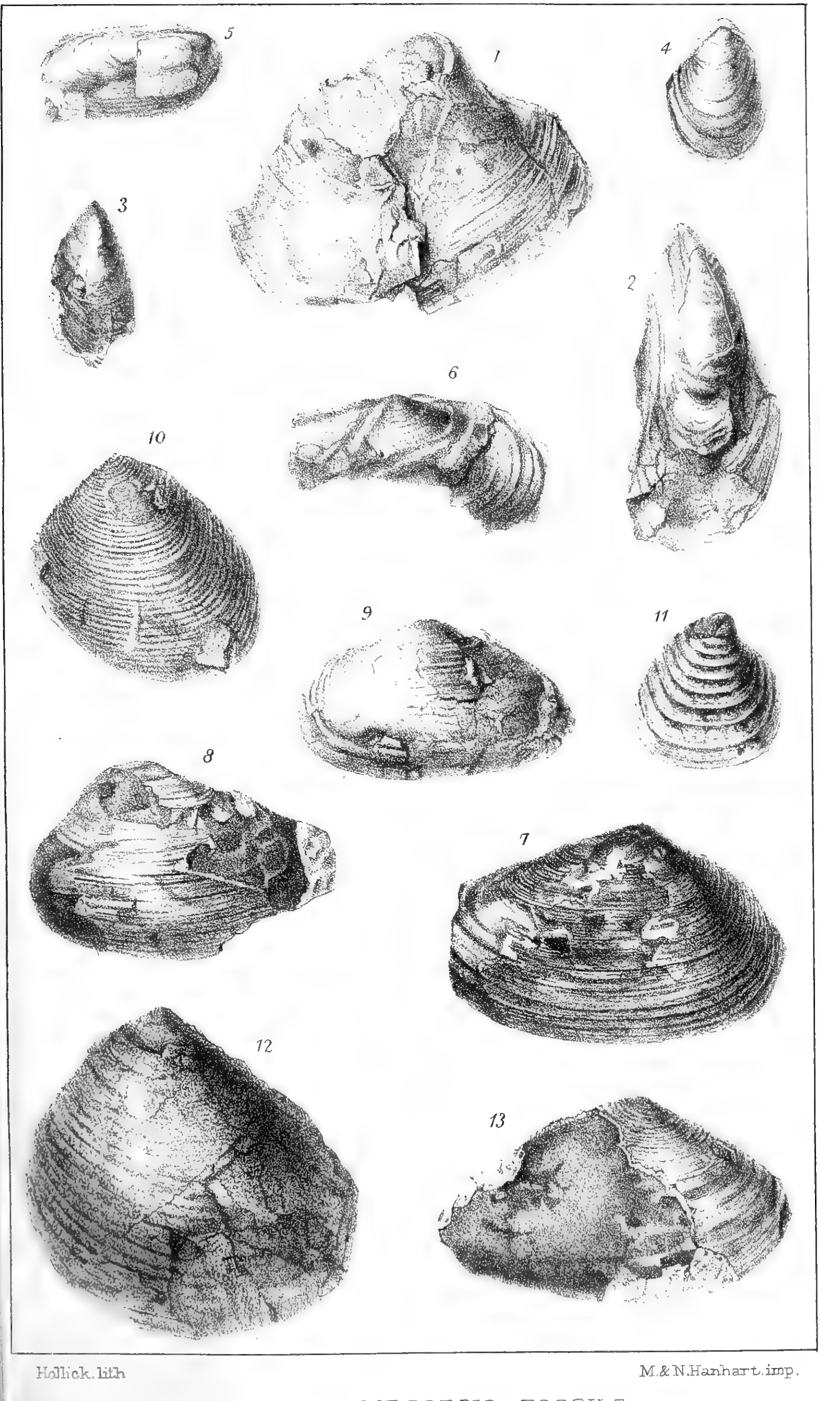
AUSTRALIAN MESOZOIC FOSSILS.



Hollick lith.

M. & N. Hanhart imp.

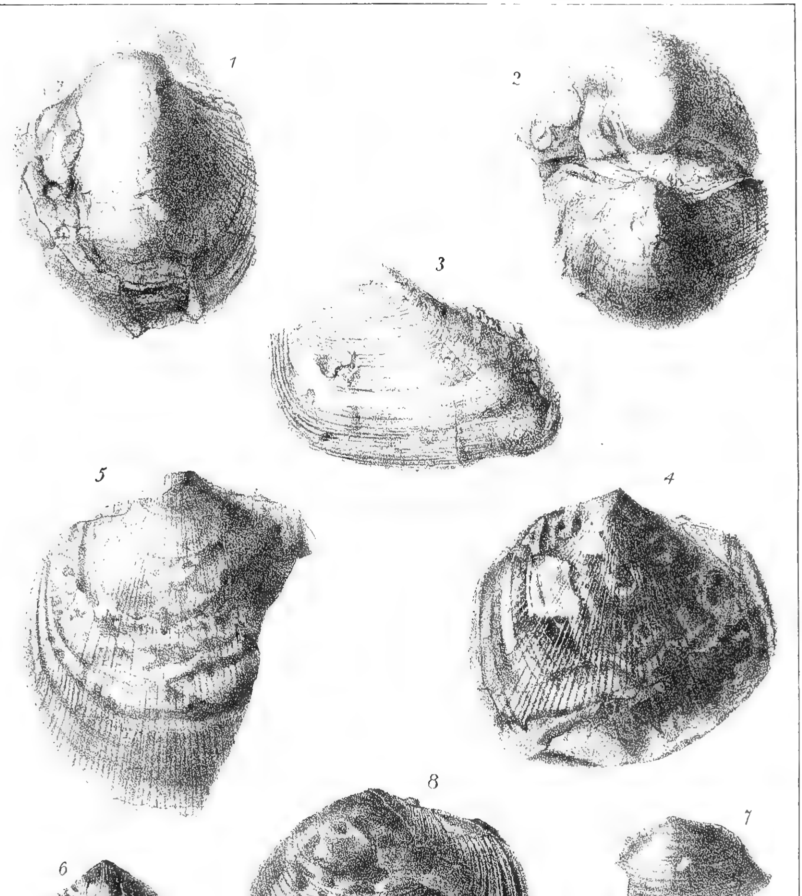
AUSTRALIAN MESOZOIC FOSSILS



Hollick. lith

M. & N. Hanhart. imp.

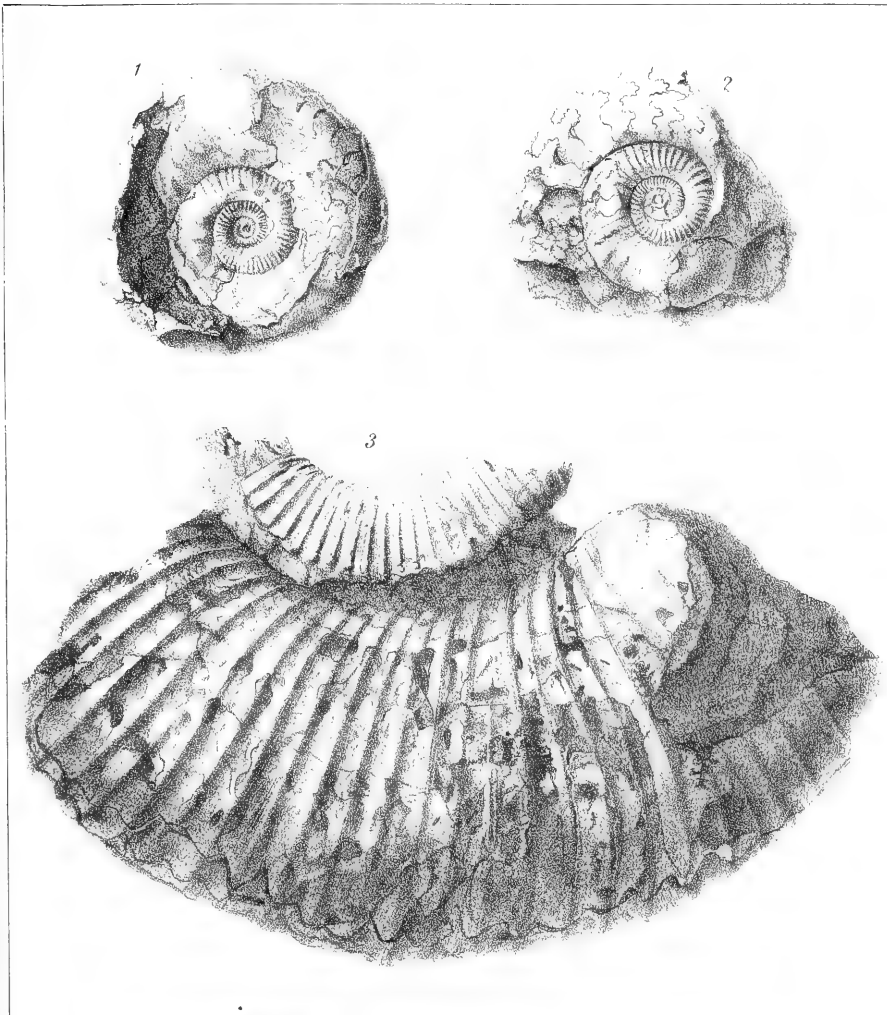
AUSTRALIAN MESOZOIC FOSSILS.



Hollick lith.

M & N Hanhart imp

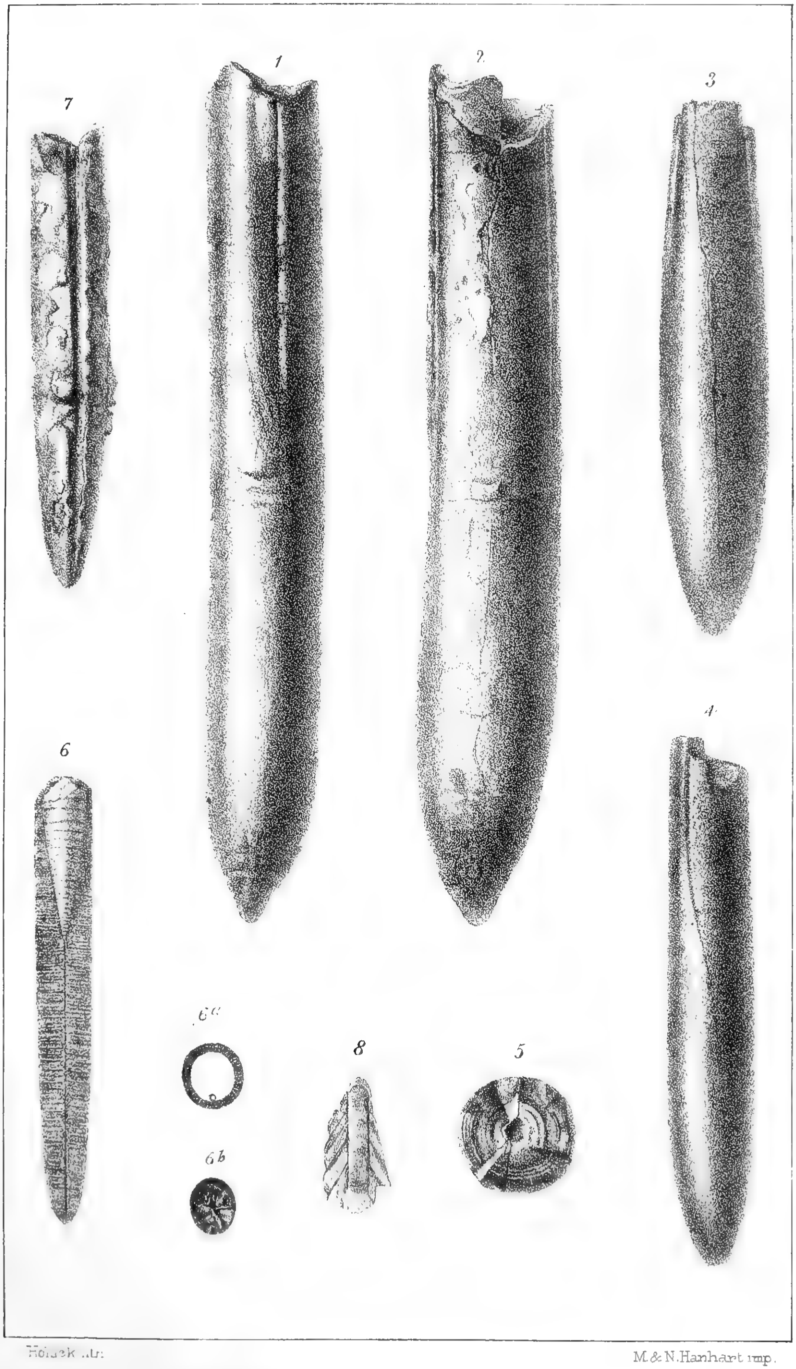
AUSTRALIAN MESOZOIC FOSSILS.



Hollick lith.

M & H. Hanhart imp.

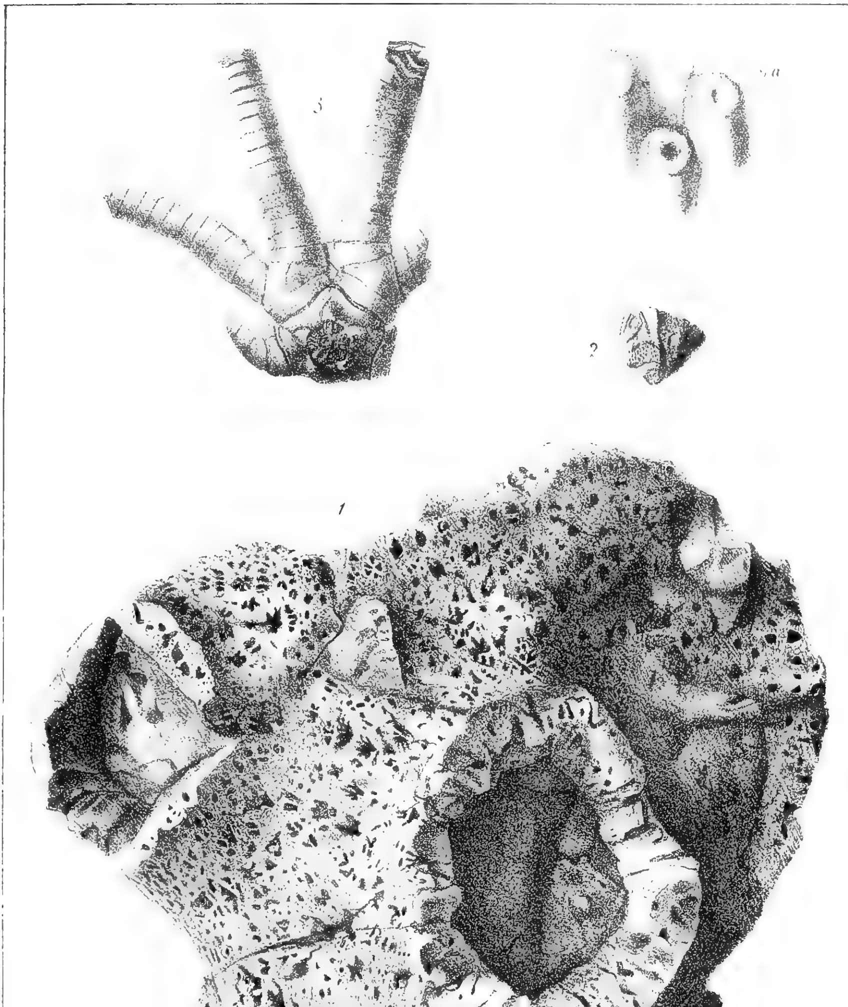
AUSTRALIAN MESOZOIC FOSSILS



Hollick lith.

M.&N.Hanhart imp.

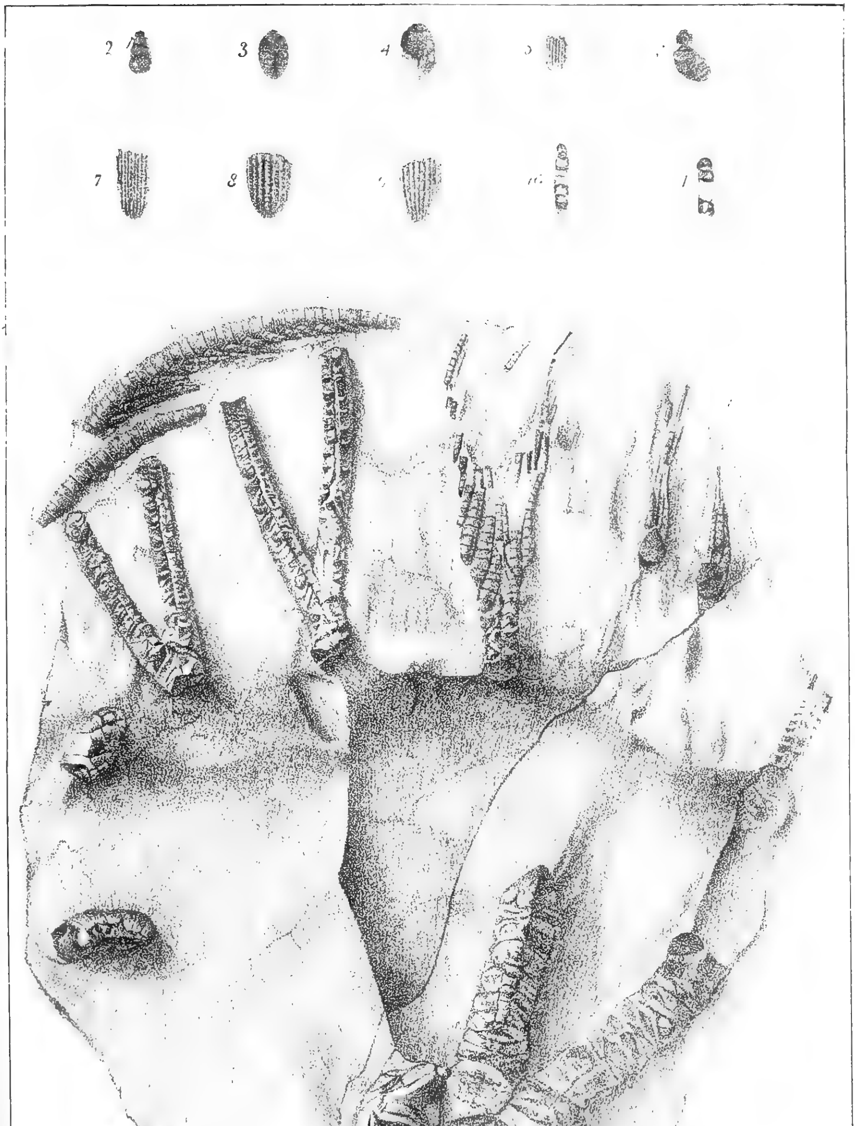
AUSTRALIAN MESOZOIC FOSSILS



Hollick lith.

M & N. Hanhart imp

AUSTRALIAN MESOZOIC FOSSILS



Hollick. lith. M & N Hanhart imp

AUSTRALIAN MESOZOIC FOSSILS AND TERTIARY INSECTS.

PLATE XV.

Fig. 1. *Ammonites aalensis*, var. *Moorei*, Lycett, reduced.
2. *A. radians*, Rein., reduced.
3. *Crioceras australe*, Moore, reduced.
4. *Ammonites Brocchii*, Sow., reduced.
5. *A. macrocephalus*, Schloth., reduced.

PLATE XVI.

Fig. 1. Lateral view of *Belemnites australis*, n. sp., showing the lateral groove with partial interruptions. From Queensland.
2. Ventral aspect of the same, showing no groove along the middle, but two lateral grooves.
3. Ventral aspect of a younger specimen, showing two lateral grooves, but no ventral groove. From Ward Creek.
4. Lateral aspect of the same, showing the lateral groove and its flexure.
5. Cross section of the guard behind the alveolar apex.
6. Section of *Belemnites paxillosus*?, showing phragmocone, canal, and dorsal striæ, nat. size.
6 *a*. Section showing alveolar chamber and siphuncular tube.
6 *b*. Section of the guard.
7. *Belemnites canaliculatus*, Schlot., showing canal.
8. *Teuthis* (?), fragment of the pen, enlarged.

PLATE XVII.

Fig. 1. *Purisiphonia Clarkei*, Bowerbank.
2. *Lepralia? oolitica*, Moore; 2 *a*, three cells magnified.
3. *Pentacrinus australis*, Moore, showing base of pelvis.

PLATE XVIII.

Fig. 1. *Pentacrinus australis*, Moore, showing the interior of the pelvis and the structure of the arms.

---

2. *Notes on a* PLANT- *and* INSECT-BED *on the* ROCKY RIVER, NEW SOUTH WALES. By CHARLES MOORE, F.G.S.

(Read November 10, 1869 *.)

[PLATE XVIII.]

SINCE my paper on Mesozoic Australian Geology was written, a lady, who had for some time resided in New South Wales, whilst on a visit in Bath, requested me to look at some minerals she had brought with her from Australia; and these consisted chiefly of auriferous quartz, variegated sandstones, and other specimens most likely to attract a lady collector. Amongst them, however, was a block, a few inches square, of what was supposed to be coal, which at first view looked very much like the Tertiary brown coal of Germany, and which Dr. von Hochstetter, in his account of the Geology of New Zealand, has shown to occur extensively in that colony. Its examination led me to observe that it was not bituminous, and that it was only a piece of chocolate-coloured, micaceous, laminated marl. Thinking it possible that it might contain Microzoa, the request that I might have it for examination was readily assented to.

A memorandum on the block of marl indicated that the bed from which it came was ten feet thick, and that it was met with in sinking a shaft for gold, at a depth of from 100 to 110 feet, on the banks of the Rocky River, Sydney Flats.

* See p. 2 of the present volume of the Journal.

In the New-South-Wales Catalogue of the International Exhibition, T. Dalton, Esq., remarks, on the Rocky-River district, that vegetable remains were found in a silicified state amongst the lowest strata of sand, resting upon the granites, beneath the basalt on all parts of this gold-field. Respecting the clays that intervene between the basalts and drifts of quartzose sand, he says, "In some cases these clays alternate with sand-drifts. There is no sheet or stratum of clay extending over the entire Flat at any given depth beneath the basalts; on the contrary, they vary in colour and thickness in almost every claim; on the southern part of the Flat, buff, black, and pure white predominate. All these sands and clays appear to have been derived from the decomposition of the neighbouring granites and their quartz-veins."

"Sydney Flat is a depression situated just beneath the basaltic plains that form the summit of the main range. It is bounded on the south by Mount Jones, and on the north by Dogherty's Hill. The granite under Mount Jones crosses Sydney Flat, and, passing under Dogherty's Hill, maintains a general level, with the exception of bars trending north or north-east, the channels between which are full of now soft granite, which falls to pieces at the touch."

I have already pointed out* that the surface of the Australian continent appears to have been subject to great denudation, the Sydney Flat district being another evidence of the fact, in which thick drifts and dense conglomerates have to be passed through, with occasional beds of clay or marl, to reach the auriferous deposits of the granitic basin below; whilst these are, in their turn, covered up by basalts of probably Tertiary or Posttertiary age.

It would appear, at first view, that drifts of such great thickness, and covering so large an area, must have been attended by phenomena altogether unfavourable to the preservation of the more delicate organisms of the period when they were deposited; but, on the contrary, it will be seen that not only the vegetation but the most fragile insect-life of the period may be found in the marls and clays intercalated with the auriferous drifts of the Rocky-River district. It is probable from this that the drifts have been deposited at varying intervals, and that there have been periods of repose within which the laminated marls and clays, which are associated with them, were slowly accumulated in the basins in which they are now found, whilst often these may have again been partially denuded by the recurrence of the phenomena which produced the drifts above them, and with which they are associated.

On proceeding to examine the piece of laminated marl, I detected the presence of vegetable remains, and soon succeeded in opening up a tolerably perfect leaf, though wanting its apex, of some dicotyledonous plant. This was followed by a second leaf, belonging to the same order, but to a different plant; whilst a third genus is shown by the upper part of a flat narrow leaf, evidently allied to the Coniferæ. The last appears to be abundant, as three or four examples were present, one or two of which were sufficiently well

* *Vide suprà*, p. 233.

preserved to be separated from the matrix. In addition to these, there is what appears to be a seed-vessel, of an oval shape, whilst the impressions of what are probably other seeds are to be detected on the laminæ of the marl.

Mr. Carruthers, of the British Museum, who has been kind enough to examine the specimens, thinks it undesirable, as they are not quite perfect, to assign them a place or generic position, without further examples; but he states that they are probably of Tertiary age, although similar dicotyledonous leaves occur in the Secondary rocks of North America, and also, though more rarely, in those of Europe.

It was my intention (having observed these specimens) to remark on the probability of finding fossil insects in association with these plants, and to advise my Australian friends to keep a look-out for them. Subsequently, however, by a closer examination of the marl itself, I had the pleasure of detecting their existence in it, and of obtaining evidence of the presence of the earliest known fossil insects in Australia. The first which attracted my attention was a small, black, shining, highly ornamented elytron of a beetle, partly concealed in the matrix; but in endeavouring to uncover it, the specimen sprang out bodily, and proved too brittle to be preserved. Ten other insects were afterwards obtained from the same block. The most abundant belong to the Coleoptera, both double and single elytra being present, some of them having the punctate striæ well preserved. There are single specimens which may belong to *Cyphon*, and also a minute annulose body which may be a larva.

As some of these insects are very small, it will be undesirable at this time to do more than record their presence in the Australian Tertiary deposits, leaving their description until a larger series shall have been obtained. There can be no doubt, from the apparent abundance of both plants and insects, that a rich harvest awaits those palæontologists who will give attention to these interesting beds.

EXPLANATION OF PLATE XVIII. Figs. 2–11.

2–9. Remains of Coleoptera, from New South Wales.
10. Larva, probably of *Oxytelus*, from New South Wales.
11. Insect, probably allied to *Cydnus*, from New South Wales.

DONATIONS

TO THE

LIBRARY OF THE GEOLOGICAL SOCIETY.

From October 1st to December 31st, 1869.

I. TRANSACTIONS AND JOURNALS.

Presented by the respective Societies and Editors.

Academy (Journal). Nos. 2 & 3. November and December 1869.

American Academy of Arts and Sciences. Proceedings. Vol. vii. pp. 345–525. 1868.

American Journal of Science and Arts. Second Series. Vol. xlviii. No. 143. September 1869.

E. Andrews.—On some Remarkable Relations and Characters of the Western Boulder Drift, 172.
G. J. Brush.—On Durangite, a fluo-arsenate from Durango in Mexico, 179.
An Account of the Swedish North-Polar Expedition of 1868, under the command of A. E. Nordenskiöld and F. W. von Otter, 227.
A. E. Verrill.—Description of some new American Phyllopod Crustacea, 244.
J. L. Smith.—On the Lesleyite of Chester C., Penn., and its relation to the Ephesite of the Emery formation near Ephesus, Asia Minor, 254.

American Naturalist. Vol. iii. Nos. 8 & 9. October and November 1869.

B. M. Wright, Jun.—Sponges, 449.
Eozoön in Essex County, 498.

Art-Union of London. Thirty-third Annual Report. 1869.

Athenæum (Journal). Nos. 2188–2199. October to December 1869.

Mountains and Mole-hills, 464.
Geologizing in North Tynedale, 565, 630.
D. Mackintosh.—Denudation of Abyssinia, 702.
C. Beke.—The Sources of the Nile, 737.
R. B. Smyth.—The Gold-fields and Mineral Districts of Victoria, 822.

Berlin. Monatsbericht der königl.-preussischen Akademie der Wissenschaften zu Berlin. July to October 1869.

——. Zeitschrift der deutschen geologischen Gesellschaft. Band xxi. Hefte 2 & 3. February to July 1869.

— Zeuschner.—Ueber die neuentdeckte Silurformation von Kleczanów bei Sandomiez im südlichen Polen, 257.
——. Geognostische Beschreibung der mittleren Grzegorzowice und Skaly-Zagaje bei Nova Slupia, 263.
K. von Seebach.—Ueber die Eruption bei Methana im dritten Jahrhundert vor Chr. Geb., 275.
K. A. Lossen.—Metamorphische Schichten aus der paläozoischen Schichtenfolge des Ostharzes, 281.
R. Richter.—Das thüringische Schiefergebirge, 341 (2 plates).
——. Myophorien des thüringischen Wellenkalks, 444 (1 plate).
H. Eck.—Die Bohrversuche bei Heppens, 458.
H. Laspeyres.—Ueber Geschiebe mit geborstener Oberfläche, 465.
A von Groddeck.—Ueber die schwarzen Oberharzer Gangthonschiefer, 500.
H. Credner.—Die vorsilurischen Gebilde der "Oberen Halbinsel von Michigan," in Nord-Amerika, 516 (2 plates).
C. Rammelsberg.—Ueber die Constitution einiger natürlichen Tantal- und Niobverbindungen, 555.
— Zeuschner.—Ueber *Belemnites Bzoviensis*, eine neue Art aus dem untersten Oxfordien von Bzow bei Kromolow, 565 (plate).
——. Ueber den silurischen Thonschiefer von Zbrza bei Kielce, 569 (plate).
A. Lasard.—Neue Beiträge zur Geologie Helgolands, 574 (plate).
A. von Koenen.—Ueber die Tertiärversteinerungen von Kiew, Budzak und Traktemirow, 587 (plate).
F. von Richthofen.—Mittheilungen von der Westküste Nordamerikas, 599.
A. Sadebeck.—Ueber die Krystallformen der Blende, 620 (plate).
——. Allegemeines Gesetz für tetraëdrische Zwillingsbildung, 640.
— Kosmann.—Eine Pseudomorphōse von Eisenoxydhydrat nach Weissbleierz, 644.
A. Kunth.—Beiträge zur Kenntniss fossiler Korallen, 647 (2 plates).
C. Rammelsberg.—Ueber die Zusammensetzung und die Constitution des Axinits, 689.

Bordeaux. Actes de la Société Linnéenne de Bordeaux. Tome xxvi. 3e Série. Tome vi. 2me Partie. 1868.

T. Billiot.—Coupes Géologiques des Sondages exécutés dans le Sud-ouest de la France (Gironde, Auch et Dax), 241.
C. Des Moulins.—Liste des principaux fossiles recueillis par les Membres de la Société à Cazeneuve dans le Calcaire de Bazas, 293.
——. Descriptions et Figures de quelques Coquilles fossiles du Terrain tertiaire et de la Craie (Gironde, Dordogne, Royan), 357.
— Benoist.—Note sur le grès infraliasique du Département de la Meurthe, 380.
— Linder.—Etude sur les Terrains de Transport du Département de la Gironde, 385.
— Benoist.—Notes pour servir à l'étude des Etages jurassiques inférieurs des environs de Nancy, 561.

Breslau. Abhandlungen der schlesischen Gesellschaft für vaterländische Cultur. Abtheilung für Naturwissenschaften und Medicin. 1868–69.

H. R. Göppert.—Ueber algenartige Einschlüsse in Diamanten und über Bildung derselben, 61.

——. ——. Philosophisch-historische Abtheilung. 1868. Heft ii.

——. Sechsundvierzigster Jahres-Bericht der schlesischen Gesellschaft für vaterländische Cultur. 1868. Breslau, 1869.

F. Römer.—Ueber Auffindung einer sandigen cenomanen Kreidebildung unter dem kalkigen turonen Kreidemergel von Oppeln, 32.
——. Ueber die drei neuen Sectionen (Woischnik, Guttentag, Creutzburg) seiner geognostischen Karte von Oberschlesien, 33.
——. Ueber Auffindung von Graptoliten in schwarzen Kieselschiefern bei Willenberg (Schönau) im Katzbachthale, 35.
——. Ueber die Section Brieg seiner geognostischen Karte von Oberschlesien, 36.
——. Ueber einige Quarzgerölle mit Eindrücken, von Kohlendorf in der Grafschaft Glatz, 37.
F. Cohn.—Ueber Entstehung der Steinkohle aus Seetang, 38.
— Grube.—Ueber Ehlers' Entdeckungen fossiler Euniciden und eine neue *Diopatra*, 58.
H. R. Göppert.—Ueber die in Braunkohlenlagern von Naumburg a. B. gefundenen, von Heer als *Nyssa* bestimmten fossilen Früchte, 123.

Buenos Aires. Anales del Museo publico, por German Burmeister. Entrega sexta. 1869.

Calcutta. Asiatic Society of Bengal. Proceedings. Nos. 8 & 9. August and September 1869.

Canadian Journal. New Series. Vol. xii. No. 3. July 1869.

E. J. Chapman.—Notes on the Silver Locations of Thunder Bay, 219.

Canadian Naturalist and Quarterly Journal of Science. New Series. Vol. iv. No. 3.

Chemical News. Vol. xx. Nos. 514–525.

Chemical Society. Journal. Second Series. Vol. vii. October to December 1869.

Colliery Guardian. Vol. xviii. Nos. 457–468.

Copenhagen. Oversigt over det Kongelige danske Videnskabernes Selskabs Forhandlinger. 1867, Nos. 6 & 7; 1868, Nos. 1–4; and 1869, No. 1.

Devonshire Association. Report and Transactions. Vol. iii. 1869.

G. W. Ormerod.—Notice of Molars of *Hippopotamus major*, stated to have been found in Kent's Cavern, Torquay, 79.
——. Notice of the Occurrence of Scapolite at Chagford, Devon, 80.
W. Pengelly.—On the Submerged Forest at Blackpool, near Dartmouth, South Devon, 127.
P. O. Hutchinson.—Fossil Elephant's Tooth, 143.
W. Pengelly.—The Literature of Kent's Cavern, 191.

Dorpat. Archiv für die Naturkunde Liv-, Esth-, und Kurlands. Erste Serie. Mineralogische Wissenschaften. Band iv. Dorpat, 1868.

A. Kuhlberg.—Die Insel Pargas (Åhlön), chemisch-geognostisch untersucht, 115.

J. Lemberg.—Die Gebirgsarten der Insel Hochland, chemisch-geognostisch untersucht, 175, 337.

Geological Magazine. Vol. vi. Nos. 10–12. October to December 1869.

H. W. Bristow and W. Whitaker.—On the Formation of the Chesil Bank, Dorset, 433 (2 plates).

W. Whitaker.—On a Raised Beach at Portland Bill, Dorset, 438 (1 plate).

E. Ray Lankester.—On the Discovery of the Sabretoothed Tiger in the Norfolk Forest-bed at Cromer, 440 (1 plate).

G. A. Lebour.—On the Denudation of Western Brittany, 442.

S. Sharp.—Notes on the Northampton Oolites, 446.

Prof. Owen.—Notes on two Ichthyodorulites, 481.

T. G. Bonney.—On the supposed *Pholas*-burrows in the Ormesheads, 483 (1 plate).

C. E. de Rance.—On the Surface-geology of the Lake District, 489.

H. A. Nicholson.—On the Occurrence of Plants in the Skiddaw Slates, 494 (1 plate).

W. Whitaker.—On the Connexion between Geology and the Consumption Death-rate, 499.

J. Ruskin.—On Banded and Brecciated Concretions, 529 (1 plate).

H. Hicks.—On *Eophyton* in the Lower Arenig Rocks of St. David's, 534 (1 plate).

G. P. Scrope.—On the Pretended Raised Seabeaches of the Inland Slopes of England and Wales, 535.

Prof. Harkness.—On the Middle Pleistocene Deposits of Britain, 542.

R. Tate.—Additions to the Lists of British Brachiopoda of the Secondary Rocks, 550.

Catalogue of Type Fossil Fishes in the Museum of the Earl of Enniskillen, 556.

W. H. S. Westropp.—On the Occurrence of "Albite" in the Granite of Leinster, 561.

Prof. Harkness's Address to Section C at the British Association, Exeter, noticed, 448.

Liverpool Geological Society's 'Proceedings,' noticed, 562.

Mr. Charles Moore's 'Report on Fissures and their organic contents,' noticed, 563.

Dolfus et Montserrat's 'Voyage géologique dans les Républiques de Guatemala et de Salvador,' reviewed, 455.

R. B. Smyth's 'Gold-fields and Mineral Districts of Victoria,' reviewed, 459.

Lartet and Christy's 'Reliquiæ Aquitanicæ,' reviewed, 463.

Mackintosh's 'Scenery of England and Wales,' reviewed, 465.

'Transactions of the Woolhope Club,' reviewed, 470.

Baily's 'Characteristic British Fossils,' reviewed, 471.

Sir W. Thomson's 'Geological Dynamics,' reviewed, 472.

L. C. Miall.—'Experiments on the Contortion of Mountain Limestone,' noticed, 505.

J. E. Taylor.—'On certain phenomena in the Norwich Drift,' noticed, 508.

Geological Magazine. Vol. vi. Nos. 10–12 (*continued*).

Baron Richthofen's 'Natural System of Volcanic Rocks,' reviewed, 510.

Delesse et De Lapparent's 'Revue de Géologie,' reviewed, 516.

Miss Eyton's 'Geology of North Shropshire,' reviewed, 518.

G. H. Morton's 'Geology of the country around Shelve,' reviewed, 519.

W. Molyneux's 'History of Burton,' reviewed, 520.

Mr. Waterhouse Hawkins's 'Restorations of Extinct Dinosauria,' reviewed, 565.

'Memoirs of the Geological Survey of Ireland,' reviewed, 567.

Royal Agricultural Society's 'Journal,' reviewed, 569.

Reports and Proceedings of Societies, 476, 521, 571.

Correspondence, 523, 574.

Miscellaneous, 528, 576.

Ireland. Journal of the Royal Geological Society. Vol. xii. Part 2. 1869.

W. Harte.—On a new Echinoderm (Spatangoid), supposed to be from the Yellow Sandstone of Scotland, 135.

J. E. Reynolds.—Note on the Formation of Dendrites, 136.

——. On some Points in the Classification of the Silicates, 139.

T. J. Nicolls.—Note on the Occurrence of Anthracite in the Carboniferous Limestone of Castleknock, 149.

W. H. S. Westroop.—Sketch of a Classification of Minerals, founded on Modern Chemical Theories, 152.

J. S. Moore.—On the Chronology of the Tertiary Epoch, 162 (2 plates).

S. Haughton.—On the Theory of Secondary Joints, as illustrated by Mr. Hull's Paper on the Lines of Elevation of the Pendle Hills, in Lancashire, 163.

J. E. Reynolds.—Note on Specimens of Rutile from the County Mayo, 164.

S. Haughton.—Notes on a Comparison of the Granites of Cornwall and Devonshire with those of Leinster and Mourne, 166.

G. V. Du Noyer, a Letter from, On the Flint Flakes of Antrim and Down, 169 (1 plate).

J. S. Moore.—On the Growth of Turf Bogs of fibrous character, 171.

——. On the Discovery of a Cache at Ballinatona, near Blesinton, 174.

W. L. Lindsay.—The Gold-fields of Scotland, 176 (2 plates).

A. Macalister.—Notes on some Irish Crania from the County Tipperary, 188.

J. E. Reynolds.—Notes on the Felspars, 196.

Leeds. Philosophical and Literary Society. Annual Report for 1868–69.

London, Edinburgh, and Dublin Philosophical Magazine. Fourth Series. Vol. xxxviii. Nos. 255–257. October to December, 1869. *From Dr. W. Francis, F.G.S.*

Geological Society's Proceedings, 465.

Longman's Notes on Books. No. 59. 1869.

Medical Press and Circular. New Series. Vol. viii. Nos. 14–23.

Milan. Atti della Società Italiana di Scienze Naturali. Vol. xi. Fasc. 3 & 4. February and April, 1869.

Sezione di Geologia, 394.
Botti, U.—Sopra un ittiolito della calcarea tenera leccese, 497.
Ferrero, L. O.—Sulle torbe lombarde e sulla loro lavorazione, 499.
Pirona, G. A.—Sopra una nuova specie di *Hippurites*, 508 (1 plate).
Calderini, P.—La Geognosia e la Geologia del Monte Fenera allo sbocco di Valsesia, 528.
Suess, E.—Sur la structure des dépôts tertiaires du Vicentin, 634.
Issel, A.—Di alcune ossa umane provenienti dal terreno pliocenico di Savona, 659.
Ferrero, L. O.—Saggi di combustibili, calcari, cementi e minerali lombardi, 902.

——. ——. Vol. xii. Fasc. 1. August 1869.

Seguenza.—Scoperta di un lembo di terreno cretaceo assai fossilifero nella provincia di Messina, 155.

——. Memorie del Reale Istituto Lombardo di Scienze e Lettere. Classe di Scienze Matematiche e Naturali. Vol. xi. Fasc. 2. 1869.

——. Rendiconti del Reale Istituto Lombardo di Scienze e Lettere. Serie ii. Vol. ii. Fasc. 11–16. 1869.

L. Maggi.—Nota intorno al conglomerato dell' Adda, 733.
Curioni.—Observazioni su questa Nota, 741.

Monthly Microscopical Journal. Nos. 10 & 11 (October and November), 1869.

W. Carruthers.—On the Structure of the Stems of the Arborescent Lycopodiaceæ of the Coal-measures, 177 and 225 (2 plates).
C. Moore.—Report on "Mineral Veins and their Organic Contents in Carboniferous Limestone," 182.

Munich. Abhandlungen der königlich-bayerischen Akademie der Wissenschaften. Mathematisch-physikalische Classe. Band x. Abth. 2. 1868. (2 copies.)

——. Sitzungsberichte der königl.-bayer. Akademie der Wissenschaften zu München. 1867. Band ii. Hefte 3 & 4.

C.W.Gümbel.—Ueber die geognostischen Verhältnisse des Mont-Blanc und seiner Nachbarschaft nach der Darstellung von Prof. Alph. Favre und ihre Beziehungen zu den benachbarten Ostalpen, 603.

——. ——. 1868. Band i. Hefte 1–4.

C.W. Gümbel.—Ueber den Pyrophyllit als Versteinerungsmittel, 498.

——. ——. 1868. Band ii. Hefte 1–4.

von Kobell.—Ueber den krystallisirten Spessarten von Aschaffenburg und über eine dichte Varietät von Pfitsch, 292.
——. Ueber einen Almandin aus Nord-Columbien, 295.

——. ——. 1869. Band i. Hefte 1–3.

von Kobell.—Ueber das Wasser der Hydrosilicate, 357.
——. Ueber den Aspidolith, ein Glied aus der Biotit- und Phlogopit-Gruppe, 364.
——. Ueber einen Paragonit von Virgenthal in Tyrol, 366.

Naturalist's Note-Book. Vol. iii. Nos. 34–36. October to December 1869.

On Submerged Forest Trees in Cumberland Basin, 328.
A. E. Buttemer.—Rambles in Cornwall, 363.
H. H. Ulidia.—The Crust of the Earth, 374.

Nature (Journal). Vol. i. Nos. 1–7.

Prof. Huxley.—Triassic Dinosauria, 23.
H. Woodward.—Geology and Agriculture, 46 (with map).
J. D. Hooker.—Vegetable Palæontology, 48.
J. Evans.—Prehistoric Archæology, 77.
D. Forbes.—Depths of the Sea, 100.
D. Forbes.—Sermons in Stones, 130.
N. Story Maskelyne.—Dana's 'Mineralogy,' noticed, 161, 186.
W. A. Bell.—New Tracts in North America, 163.

Neues Jahrbuch für Mineralogie, Geologie, und Paläontologie. Hefte 4–6, 1869.

G. vom Rath.—Aus Norwegen, 385.
A. v. Groddeck.—Ueber ein neues Vorkommen von sogenanntem Silbersand zu Andreasberg, 445.
G. Laube.—Ueber Oolaster, ein neues Echinoiden-Geschlecht aus den eocänen Ablagerungen von Mattsee in Oberösterreich, 451 (1 plate).
H. B. Geinitz.—Ueber fossile Pflanzenreste aus der Dyas von Val Trompia, 456 (1 plate).
——. Ueber fossile Pflanzen aus der Steinkohlen-Formation am Altai, 462.
H. Laspeyres.—Ueber das Zusammen-Vorkommen von Magneteisen und Titaneisen in Eruptiv-Gesteinen und über die sogenannten petrographischen Gesetze, 513.
C. W. Gümbel.—Eozoon im körnigen Kalke Schwedens, 551.
A. v. Lasaulz.—Petrographische Studien an den vulcanischen Gesteinen der Auvergne, 641.
R. Ludwig.—Ueber die Gliederung der devonischen Formation im Dillenburgischen und Biedenkopfischen Theile des Westerwaldes, 658.
C. Fuchs.—Bericht über die vulcanischen Ereignisse des Jahres 1868, 686 (1 plate).
F. Klocke.—Ueber das Vorkommen von Pseudomorphosen von Buntsandstein nach Kalkspath in den Umgebungen von Heidelberg, 714.

New South Wales. Transactions of the Royal Society, for the year 1867. Vol. i. 1868.

Gerard Krefft.—Remarks on a paper by S. H. Wintle on the Bones found in a cave at Glenorchy, Tasmania, 30.
W. B. Clarke.—On the Auriferous and other Metalliferous Districts of Northern Queensland, 42.
——. Note on the Geology of the Mary River, 76.

Paris. Bulletin de la Société Géologique de France. Deuxième Série. Tome xxvi. No. 3. 1869.

Coquand.—Sur la formation crétacée de la montagne de la Clape, 193.

Paris. Bulletin de la Société Géologique de France. Deuxième Série. Tome xxvi. No. 3 (*continued*).

Hébert.—Classification des assises néocomiennes.—Réponse à M. Coquand, 214.

Jaubert.—Sur les formations jurassiques du versant nord du mont Lozère, 216.

Tabariès.—De quelques terrains cristallins, sédimentaires et glaciaires de la Corse, 266.

De Loriol.—Sur l'étage valangien des carrières d'Azier, 274.

Leymerie.—Sur la division inférieure du terrain crétacé pyrénéen, 277 (2 plates).

Bombicci.—Sur la théorie des associations polygéniques, appliquée à l'étude et à la classification des minéraux, 336.

Fabre.—Sur la base de l'oolithe inférieure dans les environs de Nancy, 353.

Falsan et Chantre.—Sur le tracé d'une carte géologique du terrain erratique dans le bassin du Rhône, 360.

De Roys.—Sur les formations d'eau douce supérieures aux sables de Fontainebleau, 376.

——. Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences. Deuxième Semestre 1869. Tome lxix. Nos. 11–18.

— Guyon.—Sur un tremblement de terre qui vient d'avoir lieu à Batna, province de Constantine, 650.

Alph. Milne-Edwards et Alf. Grandidier.—Nouvelles observations sur les caractères zoologiques et les affinités naturelles de l'*Æpyornis* de Madagascar, 801.

— Hébert.—Recherches sur la craie du nord de l'Europe, 943.

Philadelphia. Journal of the Academy of Natural Sciences. New Series. Vol. vi. Part 3. 1869.

——. Proceedings of the Academy of Natural Sciences. 1868.

E. D. Cope.—Remarks on fragments of a large Enaliosaurian, 92.

T. D. Rand.—On a new Mineral in Cryolite, 142.

E. D. Cope.—Account of the discovery of the fresh-water origin of certain deposits of Sand and Clays in West New Jersey, 159.

——. Remarks on some remains of extinct Cetacea, &c., 160.

Isaac Lea.—Descriptions of Unionidæ from the Lower Cretaceous Formations of New Jersey, 162.

J. Leidy.—Notice of some Vertebrate Remains from Harden C., Texas, 174.

——. Indication of an *Elotherium* in California, 177.

——. Notice of some Reptilian Remains from Nevada, 177.

——. Notice of some Vertebrate Remains from the West Indian Islands, 178.

E. D. Cope.—Second contribution to the History of the Vertebrata of the Miocene period of the United States, 184.

J. Leidy.—Notice of some Remains of Horses, 195.

——. Notice of some extinct Cetaceans, 196.

——. Remarks on a Jaw-fragment of *Megalosaurus*, 197.

——. Remarks on *Conosaurus* of Gibbes, 200.

——. Notice of American species of *Ptychodus*, 205.

E. D. Cope.—Synopsis of the Extinct Batrachia of North America, 208.

Philadelphia. Proceedings of the Academy of Natural Sciences. 1868 (*continued*).

F. A. Genth.—Observations on the occurrence of Cupriferous Ores in Texas, 227.
J. Leidy.—Notice of some remains of Extinct Pachyderms, 230.
E. D. Cope.—On some Cretaceous Reptilia, 233.
R. P. Stevens.—Remarks on the Geology and Mineralogy of Venezuela, 303.
J. Leidy.—Notice of some remains of extinct Insectivora from Dakota, 315.
F. B. Meek and A. H. Worthen. Note on some points in the structure and habits of the Palæozoic Crinoidea, 323.
——. Remarks on some types of Carboniferous Crinoidea, with descriptions of new genera and species of the same, and of one Echinoid, 335.

Photographic Society. Journal. Nos. 210–212. October to December 1869.

Plymouth. Annual Report and Transactions of the Plymouth Institution and Devon and Cornwall Natural-History Society. Vol. iii. Part 2. 1868–69.

Puy, Annales de la Société d'Agriculture du. Vol. xxviii. 1866–67.

H. Vinay.—Découverte de coquilles marines fossiles, 341.

Quarterly Journal of Science. No. 24. October 1869.

W. Crookes.—On the Spectral Phenomena of Opals, 481 (2 plates).
F. C. Danvers.—Coal-washing, 487.
The Mineralogical Resources of Ireland, 500.
Chronicles of Geology and Mineralogy, 542, 553.

Quekett Microscopical Club. Journal. No. 8. October 1869.

Royal College of Surgeons. Calendar. 1869.

Royal Geographical Society. Proceedings. Vol. xiii. No. 5. November 1869.

Royal Society. Catalogue of Scientific Papers. Vol. iii. Gre to Lez. 1869.

St. Petersburger Zeitung. Montags-Blatt No. 22. 1869.

G. von Helmersen.—Zur Steinkohlenangelegenheit in Russland, 1.

Scientific Opinion. Vol. ii. Nos. 49–57. October to December 1869.

Prof. Owen.—On the Occurrence of Remains of the Elk (*Alces palmatus*) in British Post-Tertiary Deposits, 389.
The New Outbreak of Vesuvius, 389.
T. S. Hunt.—On the probable Seat of Volcanic Action, 426, 450.
M. E. Frassard.—On the relation between the Lherzolite and the Serpentine of the Pyrenees, 452.
The Cheshire Salt-springs, 471.
W. Boyd Dawkins.—On the Antiquity of the Iron-mines of the Weald, 492, 509.

Scientific Opinion. Vol. ii. Nos. 49–57 (*continued*).

W. Whitaker.—The Relation of Geology to the Consumption Death-rate, 492, 511.
N. S. Shaler.—On the Concentric Structure of Granitic Rocks. Part I., 505.
The Asphalte Mines and Works of Pyrimont, Savoy, 528.
N. S. Shaler.—On the Concentric Structure of Granitic Rocks. Part II., 530.

Society of Arts. Journal. 115th Session. Nos. 880–886.

Queensland Gold-fields, 859.
Bismuth in South Australia, 860.
Mineral Statistics of Italy, 897.

——. ——. 116th Session. Nos. 887–891.

Stockholm. Kongliga Svenska Vetenskaps-Akademiens Handlingar. Ny Följd. Band v. 2nd Part. 1864.

——. Band vi. 1865–66.

G. Lindström.—Om Trias- och Jura-försteningar från Spetsbergen, 20 pages (3 plates).
A. E. Nordenskiöld.—Utkast till Spetsbergens geologi, 35 pages (2 plates).

——. Band vii. 1st Part. 1867.

C. W. Paijkull.—Bidrag till kannedomen om Islands bergsbyggnad 50 pages.

——. Öfversigt af Kongl. Vetenskaps-Akademiens Förhandlingar. Årgång 22. 1865.

L. J. Igelström.—Kondroarsenit, ett nytt Mineral från Pajsbergs jern- och manganmalms-grufva i Wermland, 3.
——. Nya och sällsynta mineralier från Vermland, 227.
G. Lindström.—Några iakttagelser öfver *Zoantharia rugosa*, 271 (2 plates).
L. J. Igelström.—Nya och sällsynta mineralier från Vermlands och Örebro län, 605.

——. ——. Årgång 23. 1866.

F. L. Ekman.—Undersökning af Wismutglans från Jordåsen vid Persberget i Wermland, 19.
C. W. Paijkull.—Mineralogiska jakttagelser, 85.
L. J. Igelström.—Nya mineralier från Wermland, 93.
H. v. Post.—Bidrag till jättegrytornas Kännedom, 125.
O. Heer.—Om de af A. E. Nordenskiöld och C. W. Blomstrand på Spetsbergen upptäckta fossila växter, 149.
P. T. Cleve och A. E. Nordenskiöld.—Om sammansättningen af jernhaltiga Kolloïd-silikater, 169.
L. J. Igelström.—Om mäktiga lager af bituminös gneiss och glimmerskiffer uti Nullaberget, Östmarks socken i Wermland, 211.
A. E. Nordenskiöld.—Undersökning af Selenmineralierna från Skrikerum, 361.
C. W. Blomstrand.—Om nya mineralier från Skåne, 369.

Stockholm. Öfversigt af Kongl. Vetenskaps-Akademiens Förhandlingar. Årgång 24. 1867.

L. J. Igelström.—Sällsynta och nya mineralier från Vermland: Manganepidot, Richterit eller Manganhornblende, Kataspilit och Hyalophan, 11.
G. Lindström.—Om Brachiopodslägtet, *Trimerella*, Billings, 252 (1 plate).
A. E. Nordenskiöld.—Laxmannit, ett nytt mineral, som åtföljer kromsyrade blyoxiden från Beresowsk, 655.
G. Lindström.—Analyser på bergarter från Spetsbergen, 671.
C. W. Paijkull.—Om Kaolin från Osmundsberget i Dalarne, 681.

——. ——. Årgång 25. 1868.

L. J. Igelström.—Bidrag till Kännedomen af Wermlands mineralier och bergarter, 29.
J. G. O. Linnarsson.—Bidrag till Westergötlands Geologi, 53.
O. Heer.—Utdrag ur ett bref rörande fossila vexter från Nordvestra Amerika insamlade af Bergmästaren Hj. Furnhjelm, 63.
F. L. Ekman.—Kemisk undersökning af "Nullabergarten," från Östmarks socken i Wermland, 123.
N. P. Hamberg.—Kemisk undersökning af vattnet uti åtskilliga brunnar i Stockholm, 159.
C. W. Blomstrand.—Om Westanå mineralier, 197.
L. J. Igelström.—Om Kalits tillgodogörande ur fältspat, 409.
G. Lindström.—Om tvenne nya öfversiluriska koraller från Götland, 419.
L. J. Igelström.—Jättegryta vid sjön Wermelen i Wermland, 453.

——. Lefnadsteckningar öfver Kongl. Svenska Vetenskaps-Akademiens' efter år 1854 aflidna Ledamota. Band i. Häfte 1. 8vo. 1869.

Student and Intellectual Observer. Vol. iv. Nos. 21–23. October to December 1869.

H. Woodward.—The Pearly Nautilus, Cuttle-fish, and their allies, 241 (2 plates).
P. M. Duncan.—The oldest Human Remains in Europe, 250.
The Moa of New Zealand, 306.
T. M. Hall.—The Raised Beaches and Submerged Forests of Barnstaple Bay, 338.

Ungarische Revue, 1869. Leipzig und Wien, 1869.

M. von Hantken.—Geologie Ungarns in allgemeinen Umrissen, 1.

Vienna. Anzeiger der k.-k. Akademie der Wissenschaften in Wien. 1869. Nos. 22–26.

——. Verhandlungen der k.-k. geologischen Reichsanstalt. 1869. Nos. 12–15.

Abdulah-Bey.—Die Umgebung des See's Kutschücktschekmetché in Rumelien, 263.
F. Foetterle.—Die geologischen Verhältnisse der Gegend zwischen Topletz, Mehadia, Kornia und Petnik in der Roman-Banater Militärgrenze, 265.

Vienna. Verhandlungen der k.-k. geologischen Reichsanstalt. 1869. Nos. 12–15 (*continued*).

U. Schloenbach.—Die krystallinischen und die älteren sedimentären Bildungen im N.W. der Almásch, 267.
——. Ueber Spaltenbildungen in den Kalken am Rande der Predetter Hochebene nördlich von Steyerdorf im Banat, 269.
D. Stur.—Die Umgebungen von Cornia, Corniareva, Teregova, und Slatina, 272.
G. Stache.—Die Klippen von Novoselica (Uj Kemencza) und Várallja (Podhorogja), 273.
H. Wolf.—Die Gebirgsglieder westlich der Strasse Kaschau-Eperies, 275.
——. Die Umgebung von Eperies, 276.
E. von Mojsisovics.—Die Umgebungen von Waidring und Fieberbrunn (Pillersee) in Nordtirol, 277.
F. Hochstetter.—Geologische Reisenotizen aus Thracien, 285.
H. Bader.—Ueber die Bitterseen des Suezkanals, 287, 311.
M. Grassi.—Ueber den jüngsten Ausbruch des Aetna, 289.
F. Sandberger.—1. *Meletta*-Schuppen in der Septarienthon-Grube zu Flörsheim am Main. 2. Culm mit *Posidonomya Becheri*, Bronn, in Spanien, 290.
A. de Zigno.—Ueber die jurassischen Bildungen in den Sette Communi (Venetien), 291.
C. L. Griesbach.—Bemerkungen über die Altersstellung des Wiener Sandsteins, 292.
F. Karrer.—Berichtigende Bemerkungen über das Alter der Foraminiferenfauna der Zwischenlagen des Wiener Sandsteines bei Hütteldorf, 295.
F. Simony.—Gletscherschliffe im oberen Traunthale, 296.
E. Mojsisovics.—Notizen über den Hallstätter Salzberg, 298.
F. Hazslinszky.—Fossilien aus den Fischschiefern bei Hanusfalva nächst Eperies, 299.
A. de Zigno.—Bemerkungen zu Prof. Schenk's Referat über die "Flora fossilis formationis oolithicæ," 307.
C. Fallaux.—Vorkommen von *A. Rouyanus* in den schlesischen Karpathen, 310.
U. Schloenbach.—Die Jahressitzung der deutschen geologischen Gesellschaft zu Heidelberg, 311.
G. Stache.—Die Section für Mineralogie, Geologie und Paläontologie auf der 43. Versammlung deutscher Naturforscher und Aerzte in Innsbruck vom 18. bis 24. September 1869, 313.
F. v. Hauer.—Jahresbericht, 323.
F. v. Richthofen.—Geologische Untersuchungen in China, 343.
J. Haast.—Saurier in der Tertiärformation Neuseelands, 350.
N. Adler.—Diamanten in Südafrika, 351.
H. v. Hochstetter.—Geologische Untersuchungen in Rumelien, aus Veranlassung der Vorarbeiten zum Baue der türkischen Eisenbahnen, 352.

Wellington. Transactions and Proceedings of the New-Zealand Institute. 1868. Vol. i. May 1869.

W. B. Mantell.—Extracts from Address on the *Moa*, 18.
J. C. Crawford.—On Building Materials for New Zealand, 25.
— Eccles.—On Coal from Preservation Inlet, 29.
Bishop of Wellington.—Notes on the Earthquake felt in Wellington on the 1st of February 1869, 33.

Wellington. Transactions and Proceedings of the New Zealand Institute. 1868. Vol. i. (*continued*).

F. W. Hutton.—On the Gold-bearing district near Rangiriri, 36.
J. C. Crawford.—On indications of Changes in the level of the Coast-line of the southern part of the North Island, 38.
J. Hector.—On Geological specimens from Golden Chain, Thames District, 45.
Dr. Rolston and Lieut. Edwin.—On the Crater of White Island, 57 (2 plates).
G. Ford.—On Thames Auriferous Quartz, 61.
J. Hector.—Analyses of Waters, 70.
J. C. Crawford.—On Boulders and Travelled Blocks in Wellington Province, 79.
J. Haast.—On the Measurements of *Dinornis* Bones, 37, 80.
J. Hector.—On the recent Earthquakes and Wave-phenomena observed in New Zealand, 42, 46, 93.
F. W. Hutton.—Notes on the Basin of Te Tarata, Rotomahana, 162.
F. W. Hutton and T. Kirk.—Description of Arid Island, Hauraki Gulf, 163.
F. W. Hutton.—On the Geology of the Island of Pakihi, 73, 167.
J. Haast.—Notes on the Rock specimens collected by H. H. Travers on the Chatham Islands, 180.
——. On the recent Earthquakes on Land and Sea, 196.
J. C. Crawford.—On the Geology of the North Island of New Zealand. (Essays) pp. 27.

II. PERIODICALS PURCHASED FOR THE LIBRARY.

Annales des Sciences Naturelles. Zoologie et Paléontologie. 5e Série. Tome xi. No. 6. 1869.

——. ——. ——. Tome xii. Nos. 1–4. 1869.

E. Lartet.—Sur le *Trechomys Bonduellii* et sur deux autres Rongeurs fossiles de l'éocène parisien, 151 (1 plate).
A. Milne-Edwards et A. Grandidier.—Nouvelles Observations sur les caractères Zoologiques et les affinités naturelles de l'*Æpyornis* de Madagascar, 166 (11 plates).

Annals and Magazine of Natural History. Fourth Series. Vol. iv. Nos. 22–24. October to December 1869.

A. Hancock and T. Atthey.—On some curious Fossil Fungi from the Black Shale of the Northumberland Coal-field, 221 (2 plates).
H. A. Nicholson.—On some new Species of Graptolites, 231 (1 plate).
A. Hancock and T. Atthey.—Note on *Anthracosaurus*, 270.
J. W. Dawson.—On Calamites, 272.
P. M. Duncan and H. M. Jenkins.—On *Palæocoryne*, a new genus of Tubularine Hydrozoa, 287.
A. Hancock and T. Atthey.—On the Generic Identity of *Climaxodus* and *Janassa*, two Fossil Fishes related to the Rays, 322 (1 plate).
R. Howse.—Discovery of new and rare Fossils in the Marl-slate of Midderidge, 368.

Annals and Magazine of Natural History. Fourth Series. Vol. iv. Nos. 22–24 (*continued*).

T. R. Jones, W. K. Parker, and J. W. Kirkby.—On the nomenclature of the Foraminifera, 386 (1 plate).
R. Tate.—Contributions to Jurassic Palæontology, 417.
A. Milne-Edwards and A. Grandidier.—Observations on the Zoological Characters and Natural Affinities of *Æpyornis*, 437.
T. P. Barkas.—On Reptile Remains and *Climaxodus*, 438.

L'Institut. 1re Section. 37e Année. Nos. 1866–1873.

III. GEOLOGICAL AND MISCELLANEOUS BOOKS.

Names of Donors in Italics.

Ansted, D. T. On the Lagoons and Marshes on the shores of the Mediterranean. 8vo. 1869.

Baily, W. H. Figures of Characteristic British Fossils, with descriptive Remarks. Part 2.

Boston, Bulletin of the Public Library of. No. 11. *From the Boston Library.*

Brown, R. On the Geographical Distribution of the Coniferæ and Gnetaceæ. 8vo. Edinburgh, 1869.

Cautley, Sir Proby T. Report on the Ganges Canal Works. 3 vols. 8vo, and folio Atlas of Plates. 1860.

Dawson, Principal. Modern Ideas of Derivation. 8vo. 1869.

Delesse, M. Notice sur ses Travaux Scientifiques.

Duncan, P. M. First Report on the British Fossil Corals. 1868.

Essays on the subject of the Settlement of the Gold-mining population in New Zealand. 1869. *From the New-Zealand Government.*

Favre, Ernest. Description des Mollusques Fossiles de la Craie des Environs de Lemberg en Galicie. 4to. 1869.

Geologists' Association. Reports of Excursions to Oxford, Guildford, &c. 1869.

Hector, James. Abstract Report on the Progress of the Geological Survey of New Zealand during 1868–69. Wellington, 1869. *From the New-Zealand Government.*

Helmersen, G. von. Studien über die Wanderblöcke und die Diluvial-Gebilde Russlands.

——. Ueber devonische Steinkohle in Malöwka. 8vo. 1868.

Hutton, F. W. Second Report on the Thames Gold-fields, Province of Auckland. 1869. *From the New-Zealand Government.*

Igelström, Nordenskiöld, and Ekman. On the existence of Rocks containing Organic substances in the fundamental Gneiss of Sweden. 8vo. *From the Swedish Academy of Sciences.*

Jones, T. R., and H. B. Holl. Notes on the Palæozoic Bivalved Entomostraca. 8vo. 1869.

King, W. On some Palliobranchiate Shells from the Irish Atlantic. 8vo. 1868.

Lea, Isaac. Reprinted Papers from the Proceedings of the Academy of Natural Sciences of Philadelphia.

Marsh, O. C. Description of a new Species of *Protichnites* from the Potsdam Sandstone of New York. 8vo. 1869.

Meek, F. B. A Reply to some Remarks published by Prof. Swallow on certain disputed Points in the Geology of Kansas and other North-western localities.

Meissner, C. F. Denkschrift auf C. F. P. von Martius. 4to. Munich, 1869. (2 copies.) *From the Academy of Sciences of Munich.*

Memoirs of the Geological Survey of Great Britain, 1869, including:—

- Reports on the Geology of Jamaica; or Part II. of the West-Indian Survey, by J. G. Sawkins.
- The Mineral Statistics for the year 1868, by R. Hunt.
- Carboniferous Limestone, Yoredale Rocks, and Millstone Grit of North Derbyshire and the adjoining parts of Yorkshire, by A. H. Green, C. Le Neve Foster, and J. R. Dakyns.
- The Triassic and Permian Rocks of the Midland Counties of England, by E. Hull.
- Explanation of Quarter-sheet 88 S.E., part of the Yorkshire Coal-field, by A. H. Green, J. R. Dakyns, and J. C. Ward.

From the Director General of the Geological Survey.

Negri, G., ed E. Spreafico. Saggio sulla Geologia dei Dintorni di Varese e di Lugano. 4to. Milano, 1869.

Nordenskiöld, A. E. Sketch of the Geology of Spitzbergen. 8vo. Stockholm, 1867.

Omalius d'Halloy J. J. d'. Des Races Humaines ou Eléments d'Ethnographie. 8vo. 1869.

Ordnance Survey Maps of the United Kingdom, 1-inch scale. England: Sheets 106 S.W., 107 S.W. and S.E., 108 S.W., 109 N.W. Scotland: Sheet 25. Ireland: Sheets 17, 40, and 41.

——, 6-inch scale. Middlesex: 20 and 25. Aberdeen: 41, 49, 50, 64, 65, 67, 72–74, 76–79, 83-85, 87–91, 93, 96–100, 102–108,

110, 111. Argyll: 162, 163, 172, 173, 182–184, 193–195, 203, 204, 214–216, 225–228, 237, 238, 241, 242, 244, 248–250, 251–266. Perth and Sterling County Indexes. Devon: 116, 122, 124, 128, 130. Titles: Ayr, Cumberland, Durham, Forfar, Northumberland, Perth, Clackmannan, Selkirk, and Westmoreland. *From the Secretary of State for War.*

Pictet, F. J. Matériaux pour la Paléontologie Suisse. Mémoire sur les Animaux Vertébrés trouvés dans le Terrain Sidérolithique du Canton de Vaud. Supplément par MM. F. J. Pictet et A. Humbert. 4to. Geneva and Basle, 1869.

——. Rapport fait à la Session de 1869 de la Société Helvétique des Sciences Naturelles sur l'état de la question relative aux limites de la période Jurassique et de la période Crétacée. 8vo. 1869.

Renevier, E. Coupes Géologiques des deux Flancs du Bassin d'Yverdun. 8vo. 1869.

Richthofen, F. von. First Preliminary Notice of Geological Explorations in China.

Shelford, W. On the Outfall of the River Humber. 8vo. 1869.

Steen, Adolph. Om Integrationen af Differentialligninger der före til Additionstheoremer for transcendente Funktioner. 4to. 1868.

Studer, B. Erläuterungen zur 2ten Ausgabe der geologischen Karte der Schweiz. 1869.

Trautschold, H. Ueber saekulare Hebungen und Senkungen der Erdoberfläche. 8vo. Moskau, 1869.

Trutat et Cartailhac, MM. Matériaux pour l'histoire primitive et naturelle de l'Homme. Cinquième Année. 2e Série. Nos. 7–10. July to October 1869.

Victoria. Mineral Statistics of Victoria for the year 1868. Small folio. *From the Government of Victoria.*

——. Report of the Mining Surveyors and Registrars. Small folio. 30th June, 1869. *From the Government of Victoria.*

Waagen, W. Die Formenreihe des *Ammonites subradiatus.* Versuch einer paläontologischen Monographie. 8vo. Munich, 1869.

Wiltshire, Thomas. On the Chief Groups of the Cephalopoda. 8vo. 1869.

——. The Chief Groups of the Cephalopoda. 8vo. 1869. *From the Geologists' Association.*

IV. BOOKS PURCHASED FOR THE LIBRARY.

Benecke, E. W. Geognostisch-Paläontologische Beiträge. 4to. Zweiter Band. Heft 2. Munich, 1869.

Dollfus, A., et E. de Mont-Serrat. Voyage Géologique dans les Républiques de Guatemala et de Salvador. 4to. Paris, 1868.

Dumortier. Études paléontologiques sur les dépôts Jurassiques du bassin du Rhône. 8vo. Parts 2 and 3.

Ehrenberg, C. G. Ueber mächtige Gebirgs-Schichten vorherrschend aus mikroskopischen Bacillarien unter und bei der Stadt Mexiko. 4to. Berlin, 1869.

Heer, O. Miocene baltische Flora. 4to. Königsberg, 1869.

——. Ueber die Braunkohlenpflanzen von Bornstädt. 4to. Halle, 1869.

Ooster, W. A. Le Corallien de Wimmis. 4to. 1869.

Ooster, W. A. und C. von Fischer-. Protozoë Helvetica. Band II. 4to. 1869.

Unger, F. Die fossile Flora von Radoboj. 1869.

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

January 26th, 1870.

Thomas Daniel Bott, Esq., 2 Osberne Villas, Talfourd Road, Peckham; Edwin Buckland Kemp-Welch, Esq., 3 Beaumont Terrace, Bournemouth; James Parkinson, Esq., F.C.S., Sarum House, Church Road, Upper Norwood, S.; Henry Sewell, Esq., Villa del Valle, Mexico, and Thomas F. W. Walker, Esq., M.A., F.R.G.S., Athenæum Club, London, and 6 Brock Street, Bath, were elected Fellows of the Society. The Rev. Dr. Oswald Heer, of Zurich, was elected a Foreign Member of the Society.

The following communication was read:—

On the Crag of Norfolk *and* associated Beds. By Joseph Prestwich, Esq., F.R.S., President.

(The publication of this Paper is deferred.)

[Abstract.]

The author commenced by referring to his last paper, in which he divided the Red Crag into two divisions—a lower one, of variable oblique-bedded strata, and an upper one, of sands passing up into the clay known as the Chillesford clay. In 1849 he had alluded to the possibility of this clay being synchronous with the Norwich Crag. He has since traced this upper or Chillesford division of the Red Crag northwards, with a view to determine its relation to the Norwich Crag. He has found it at various places inland; but the best exhibition of it occurs in the Easton Bavant Cliffs. He there found in it a group of shells similar to those at Chillesford, and under it the well-known bed of mammaliferous or Norwich Crag, with the usual shells. The author also showed that in this cliff and the one nearer Lowestoft traces of the Forest-bed clearly set in upon the Chillesford clay. He traced these beds at the base of Horton Cliff, and then passed on to the well-known cliffs of Happis-

burgh and Mundesley. He considered the Chillesford clay to pass beneath the Elephant bed, and to represent some part of the Forest-bed. The same clay may be traced to near Weybourne. The Crag under these beds he referred to the Chillesford sands. Mention was then made of the sands and shingle above the Chillesford, for which the author proposed the names of "Southwold Sands and Shingle." These usually are very unfossiliferous; but at two or three places near Southwold the author found indications of an abundance of shells (*Mytilus* &c.) and Foraminifera in some iron-sandstones intercalated in this series. In the Norfolk cliffs these beds contain alternating seams of marine and freshwater shells. The inland range of the beds to Aldeby, Norwich, and Coltishall was next traced, and the Chillesford clay shown to be present in each section, and the sands beneath to be referable to the Chillesford sands, as already shown by other geologists, on the evidence of the organic remains. Mr. Gwyn Jeffreys, who had carefully examined the shells of the Norwich Crag for the author, stated that a considerable number of arctic species were found in the Norfolk Crag which did not occur in Suffolk. While, therefore, the Norwich Crag seems to be synchronous with a portion of the Suffolk Crag, that portion is the upper division; and therefore the triple arrangement proposed by Mr. Charlesworth and advocated by Sir C. Lyell, together with the fact of the setting in of a gradually more severe climate, pointed out by the late Dr. Woodward and by Sir C. Lyell, are confirmed.

Mr. Prestwich then referred to the origin of the materials of the Southwold shingle, and showed that, with few exceptions, they came from the south. In it he had found a considerable number of worn fragments of chert and ragstone from the Lower Greensand of Kent. He considered this a convenient base-line for the Quaternary period, as then commenced the spread of the marine gravels over the south of England, and soon after commenced the great denudations which have given the great features to the country.

Discussion.

Mr. Gwyn Jeffreys observed that no littoral shells occur in the Coralline Crag, while in the Red Crag they abound. In the Norwich Crag there is also evidence of littoral conditions, but in certain places the shells exhibit a deep-water character. In the Norwich Crag, after eliminating as derivative or extraneous certain species (as had already been done by the late Dr. Woodward), he finds, exclusive of varieties, 140 species, of which 123 are living, and 17 are supposed to be extinct. Of these 123, 101 still live in the British Seas, 12 are arctic and North American, 8 Mediterranean, and 2 Asiatic. The southern species were probably derived from the Coralline Crag. The two Asiatic species were the *Corbicula fluminalis* and *Paludina unicolor*. Twenty species in the Norwich Crag have not been found in the Red or Coralline Crag; and he therefore thought there was some difference in their geological age, the Nor-

wich Crag being more recent than the Red Crag, and its shells of an arctic or more northern kind. *Tellina balthica* he regarded as significant of brackish-water conditions. *Actæon Noæ*, a characteristic shell of the Red and Norwich Crag, had been found fossil by Prof. Steenstrup in Iceland.

Sir Charles Lyell had been struck with the similarity of the beds at Chillesford and at Aldeby, in which also the shells, though 40 in one case and 70 in the other, were very similar in character; but in neither was *Tellina balthica* found, though common in the glacial beds. He called attention to the condition of the shells as they occurred at Aldeby, and suggested that where the two shells of a bivalve were found in contact, they would probably afford some evidence whether they were derivative or not.

Mr. Searles V. Wood, Jun., was inclined to differ to a large extent from the author, especially with regard to the beds above the Chillesford clay. The sands containing *Tellina balthica* he placed as the lowest member of the glacial series; the fauna they contain is different from that of the Chillesford bed. He regarded the sand-beds at Kessingland as above the lower Boulder-clay and contorted Drift of Cromer, and considered that it might be traced as occupying this position along a great part of the coast of Norfolk. He had, in company with Mr. Harmer, surveyed a great part of the Norfolk and Suffolk district, and they intended to place their maps and sections at the disposal of the Geological Society. He recommended that any examination of the country should commence from the east rather than from the west.

Mr. Boyd Dawkins, speaking of the fossil mammalia of the Crag, mentioned that, at the base of the Crag at Horstead, immediately on the Chalk, was a bed exhibiting an old land-surface, and in this were found the principal perfect mammalian remains, whereas in the Crag above they were waterworn. But though these bones occurred in the marine deposit, the animals had lived on the land, and there was no evidence but that they belonged to a much earlier period than that at which it was submerged. He thought that the facies of the Cervidæ found at Horstead was that of an early Pliocene age. The mammals of the London Clay had in some cases become confounded with those of the Suffolk Crag; but these he regarded also as belonging to an old Pliocene land-surface. He differed from the author in not regarding the forest-bed as Quaternary, as the remains of *Rhinoceros etruscus*, *Ursus arvernensis*, and *Elephas meridionalis*, &c. had occurred in it in many cases in fine condition. He could see no reason for splitting up the Cainozoic series into four divisions, as there was no break in the life between the Tertiary and Quaternary periods. Though there might be a break in England, the forms of life were continuous from the Miocene of Pikermi on the Continent.

The President suggested that if we were to admit a Quaternary period we must go back to the Miocene, as the mammalian fauna of that period was the direct ancestor of that of the present day.

Mr. Prestwich, in reply, remarked that he did not quite agree

with Mr. Jeffreys as to the number of derivative species in the different members of the Crag. The fauna, however, required further investigation. With regard to the objections of Mr. Wood, he had not on this occasion intended going into details as to the beds above the Chillesford clays; his object had rather been to show that these latter extended over a large area, and contained in other places than Chillesford the same shells as those occurring there. He did not attach the same value to the presence of *Tellina balthica* as did Mr. Wood, it being a shell now living and found on the coast. He had not overlooked the importance of the mammalian remains; but, like Mr. Dawkins, he had felt the uncertainty which, in the case of the Crag, so often attached to their origin, and therefore had not much insisted on them. He thought the divisions of Miocene and Pliocene were well known and generally accepted; and though the division was arbitrary, he thought the setting in of the Glacial period a good epoch at which to commence the Quaternary period. If we were to go back to some break in the forms of life, we might go back indefinitely.

February 9th, 1870.

Alexander Murray, Esq., of the Geological Survey of Canada, St. John's, Newfoundland, and Frederick William Rudler, Esq., Museum, Jermyn Street, S.W., were elected Fellows of the Society.

The following communications were read:—

1. *On the* Fossil Corals (*Madreporaria*) *of the* Australian Tertiary Deposits. By P. Martin Duncan, M.B. London, F.R.S., Sec. Geol. Soc., Prof. of Geology in King's College, London.

(Plates XIX.–XXII.)

Contents.

Introduction.

The tertiary deposits of South-eastern Australia attracted the attention of those colonists who knew something about geology, very soon after the country was settled and examined.

The singular resemblance of the white limestone, chert, and flinty layers of the deposit of the sea-shore, near the entrance of the river Murray, in the Mount-Gambier district, to the chalk of Great Britain, soon struck many of the well-educated men who carried the spirit of natural-history inquiry into those wild settlements. Of

these the Rev. Julian Woods, of Penola, has proved the most diligent. He sought the palæontological advice of Prof. Busk and Prof. Rupert Jones, when he had determined that the cretaceous-looking beds were of tertiary age, and forwarded communications to this Society (Quart. Journ. 1860 & 1865), in which he maintained that the Mount Gambier tertiaries were of Crag age.

The softer rocks near the Glenelg, and far away along the Murray, were examined by explorers, and specimens were sent to this Society. Their examination tended to prove that the deposits were of the same general character as the Mount Gambier rocks; and with this impression Mr. Woods persevered in working among the strata, which, covered by basalt, have retained in the neighbourhood of Hamilton vast numbers of fossils.

Specimens of the Madreporaria were sent to me by Mr. Woods; and by searching in our Museum I added to their number. My paper, which was a supplement to his essay on the Tertiary Deposits in the Colony of Victoria, Australia (Quart. Journ. Geol. Soc. 1865, p. 389), refers to the species I determined from the specimens, descriptions of which had been published in the 'Annals and Magazine of Natural History' (3rd series, vol. xiv. no. 81, Sept. 1864; and vol. xvi. no 93, Sept. 1865). The common Echinoderm of the tertiaries was also described there, and named *Hemipatagus Forbesii*, Woods and Duncan.

The interest in the Australian tertiaries was increased in the colony by Mr. Woods's popular work, 'Geological Observations,' 1862, especially when practice and experience proved that there was some connexion between the Tertiaries and gold-finding.

The Victorian Survey has mapped the province, under great difficulties; and Selwyn, Ulrich, Daintree, and Wilkinson have made careful surveys and sections, which, whilst they add to the general knowledge furnished by Mr. Woods, give an excellent idea of the relative position and characters of the deposits. M'Coy has endeavoured to correlate the tertiary strata with the European; and the Survey has adopted the terms employed in European tertiary geology.

In 1867 I received a collection of Madreporaria from Mr. H. M. Jenkins, F.G.S., then Assistant-Secretary to this Society, which had been sent to him by Mr. Selwyn, with a fine series of shells. All the fossils had been collected by the Survey under Mr. Wilkinson, from beds in the neighbourhood of Cape Otway, which were marked upon the survey sketch map.

The present communication refers especially to this collection of Madreporaria; but it includes also a description of those forms which I have already published; for some doubtful points have been cleared up by the possession of better specimens than those upon which the species were founded. The characteristics of the whole fauna are considered in the argument concerning the age of the tertiaries.

II. Distribution of the Tertiary Fossiliferous Deposits.

The extent of the tertiary deposits in South Australia is not known to the north-west; but they cover many thousands of square

miles towards the Murray and the boundary of the province of Victoria. Probably they reach far into the interior; and it is by no means improbable that the tertiary sea divided Western Australia from the eastern provinces.

Selwyn's Survey-map of Victoria indicates the development of the Tertiaries of that province, of the basalts which frequently cover them, and of the upper tertiary beds of doubtful age, which here and there hide every thing, and reduce the luxuriant vegetation of the soils of the older rocks to scrub.

Strata of sedimentary or volcanic origin, referable to some section of tertiary or recent time, occupy probably fully one-half, or over 40,000 square miles, of the surface of Victoria. They are found resting unconformably on all the older formations, igneous and stratified, and range from the sea-level to elevations of over 4000 feet. They include groups of strata of earth, loam, sand, clay, gravel, conglomerate, ferruginous and calcareous sandstones and grits, hard, gritty rock, marble and other kinds of limestone, and various volcanic products.

The tertiary deposits, containing marine fossils, fringe the coast, and extend about sixteen miles inland on the eastern side of the province, between Wilson's Promontory and Cape Howe, resting probably upon Palæozoic rocks. On the west they form a more important series, reaching from the mouth of the Glenelg to Cape Otway. In this part of the province they extend northwards under a vast development of basalt for more than forty miles, and are well seen at Hamilton. The supporting strata are Palæozoic rocks and *Tæniopteris*-sandstones. Between Cape Otway and Wilson's Promontory, especially close to Port-Phillip Bay, these tertiary deposits are found on sandstones and on basalt. In this locality, some of the tertiaries have had an older geological age given to them than the prevailing type, and all are very fossiliferous. Far away to the north-west, the fossiliferous tertiaries have been found on the northern bank of the Glenelg; and vast plains of sand, ferruginous gravel, and clays in that region overlie the equivalent deposits of the coast-line. To the north and north-east was the old coast-line, now occupied by the Palæozoic rocks.

No tertiary deposits containing marine fossils have been found at a greater elevation than about 600 feet above the level of the sea, and no tertiary beds whatever, containing marine fossils, have been recognized east of Cape Howe, in any part of New South Wales.

The published sections of the tertiaries do not show any examples of great contortion of their strata, except near Cape Otway; and there the beds were deposited in a trough of highly contorted sandstone, and probably were more displaced by the operations of denudation and re-deposition than by any other causes. The thickness of the fossiliferous tertiaries is very variable. It is unknown in many places, and reaches to about 300 feet in the best-exposed sections, whilst, where much denudation has taken place, not more than a few feet of the rock may exist. Pure limestone, except in

the upper parts of the series, is rare; it contains there an abundance of Polyzoa, and is a deep-sea deposit. It would appear that this limestone, so well displayed under the basalt of Mount Gambier, to the west of the south-western boundary of Victoria, is better developed where it is most remote from the high Palæozoic land, in Central Victoria, and that its position in the tertiary scale is occupied, near to that origin of muddy and sandy sediments, by clays containing more or less of the latter. The upper series of Mount Gambier, called by the Rev. Mr. Woods the "Coralline crag," may be recognized at Cape Otway and in Mr. Daintree's section. In both of these localities the limestone, which closely resembles the white chalk at Mount Gambier, is impure and very much mixed with sediment and some volcanic ash. Other limestones are found low down in the fossiliferous series, and often form masses like islands in a mass of basalt; but I have not had any fossils from them.

The most fossiliferous parts of the series are yellow and brown ferruginous clays, and dark slate-coloured bands more or less sandy.

In the Cape-Otway series there is a plant-bed containing evergreen leaves, of species not belonging to the existing flora; it is sufficiently developed to lead to the belief that a temporary upheaval must have occurred, followed by a long subsidence. The deposits which collected during this subsidence resemble those of the upper part of every section of the Tertiaries. They bear witness to the action of currents, to the influx of mud and sand, lava, and volcanic ash, and prove not only that volcanic phenomena were very active close by, but that the older rocks which formed the shore to the north-east were suffering tremendous denudation.

Vast developments of clays with fossil leaves, gravels, and conglomerates were proceeding on the area of the Silurian rocks, which formed the shore and land washed by the tertiary sea, whilst the marine deposits were forming. Even at the altitude of 4000 feet water-worn gravels and boulders were collecting, in some places to the depth of 300 feet. This old gravel, resting on the worn surfaces of the Silurian rocks, is covered in many places by a basalt, whose representative is low down in the marine series on the coast and frequently forms its base.

An immense district, extending from Port Phillip to the river Glenelg, is covered with a basalt which is younger than that just mentioned. It was poured forth over the clays and marls of which the Hamilton beds are the type; and it covered the littoral and moderately deep-sea deposits which were in-shore of the deep sea, forming the chalky sediment. Mr. Woods has described its position in relation to the fossiliferous beds of Hamilton. Still later, and when these deep-sea deposits had crept over much of the subsiding in-shore series, which had or had not been covered with the basalt, another and long-continued lava-stream, accompanied by ash, poured from the Mount-Gambier district and many of the formerly active vents in Victoria. It covered up the coralline rocks, as they are called, and mixed with and included the lacustrine and river-sediments then forming; and it probably continued to flow until

very late in the time when the extinct antetypes of the existing Australian mammalian fauna flourished.

The basalt immediately above the coralline limestone limits superiorly the marine fossiliferous series. Its equivalents in time were, in all probability, the clay, the ferruginous sandstones, and the sandy limestones which cover the so-called Miocene to the northwest of the Glenelg; and these beds, which are well-developed on high ground, form the upper gold-drifts.

A great upheaval, probably affecting the whole of Central Australia, occurred after this outburst, and determined the present configuration of the land, which has suffered from no glacial conditions, but from great denudations of all kinds, the encroachment of sand, the formation of salt lakes, and repeated volcanic outbursts. It is evident that a vast basaltic layer covers the fossiliferous beds, the drift upon them, and the old rocks where they are not covered by those tertiaries to which the names of Miocene and Pliocene have been given.

The section at Spring Creek, by Mr. Daintree, exhibits the succession of beds in the marine fossiliferous tertiaries as follows:—

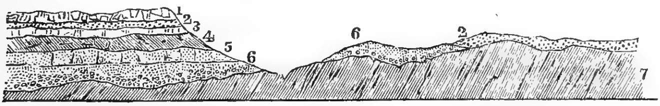
	feet.
(Upper Miocene.)	
Hard thin-bedded sandy limestone, the calcareous portion consisting almost entirely of corals	80
(Middle Miocene.)	
Soft, brown, sandy clay	80
Brown, blue, and yellow sandy clays	30
Very hard crystalline sandstone	1
Brown sandy clay poor in gypsum	12
Very hard crystalline sandstone	1
Brown sandstone containing abundance of gypsum	5
Blue marl containing septaria, gypsum, and iron-pyrites	10
Friable thin sandstone with thin bands of gypsum	8
(Lower Miocene.)	
Very hard crystalline sandstone	1
Soft brown sandstone with thin bands of harder material	4
Soft brown sandstone	13
Thin-bedded brown sandstone	20
Blue and grey friable sandstone	8
	273

M'Coy and Selwyn have used the European nomenclature; but I prefer to term the series Cainozoic; and as it appears to me that the upper member of the fossiliferous series is merely a deep-sea deposit (in a general sense) and contemporaneous with those below it, I cannot see the propriety of terming it Pliocene. The term Cainozoic is infinitely preferable here.

Nor can I distinguish between the fossiliferous series and the sands, clays, and ferruginous beds above it, except in admitting the

upper deposit to have been formed under different conditions, but whilst, generally speaking, the fauna was the same throughout the area.

Fig. 1.—*Section in Moorabool Valley, showing the relation of the Tertiaries to the older rocks and the uppermost basalt.*



The section at Moorabool Valley (fig. 1) shows :—

		feet
1.	Upper Basalt	49
2.	Sandy grit	10–15
3.	Coralline Limestone	13
4.	Older basalt enclosing hard compact bands of limestone with fossils..........................	30
5.	Sandy limestones	30
6.	Gravel and boulder-drift	90
7.	Silurian slate and sandstone with quartz veins	

The relation of the fossiliferous Tertiaries to the contorted *Tæniopteris*-sandstones, near Cape Otway, can be seen in the sketch map executed by Mr. Wilkinson.

The following is an abstract of Mr. Wilkinson's admirable survey of the Cape-Otway district *. I have added the specific names of the corals to the notices of the localities whence they were derived :—

"I will now direct your attention to the Miocene tertiary. Perhaps in no other portion of the colony can finer sections of this formation be obtained than in the cliffs along this coast. I would premise that the Carbonaceous range, which rises from the Salt Creek, near Loutit Bay, and attains an elevation of nearly 2000 feet above the sea twelve miles north of Apollo Bay, and which again falls to Moonlight Head, seems to have been, if not an island, an elevated portion of the sea-bottom during the deposition of the Miocene strata. From the present position and general horizontal manner in which the uppermost beds of this series repose on the flanks of this range, I am inclined to believe they never wholly covered it. This formation occurs at intervals from the coast east of Loutit Bay, round the north side of the Dividing Range, to Moonlight Head, and thence to Cape Otway. Though not again seen to the east of the Cape for more than forty miles, there can be little doubt that it was once continuous from Moonlight Head to Point Addis.

"The cliffs on the coast near Spring Creek, sixteen miles south of Geelong, expose a thickness of about 300 feet of Miocene strata. These have already been described in Mr. Daintree's report and geological map of that district (quarter-sheet, No. 28, S.E.); but for the sake of comparing them with the strata between Cape Otway

* Reports of the Geological Survey of Victoria.

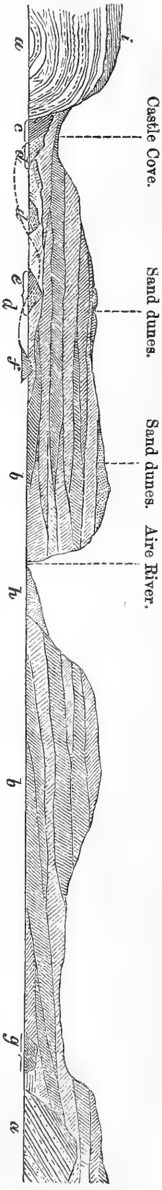
and Warrnambool, I will again refer to them. At Spring Creek [see Table, p. 288], the upper portion of the series is nearly 100 feet in thickness, consisting chiefly of yellow sandy limestone—the calcareous portion composed almost entirely of polyzoa, and fragments of echini-spines, much comminuted; but the characteristic fossils of these upper beds are *Cellepora gambierensis*, *Spatangus Forbesii* (*Hemipatagus Forbesii*, Duncan), and the little *Terebratula compta*. The middle series, which is about 150 feet thick, consists chiefly of soft brown, blue, or yellow sandy clays.

"The prevalence of *bivalve* shells is very characteristic of these beds; the most common are *Pectunculus laticostatus*, and two or three species of *Pecten*; while in the beds of the lower series *univalve* shells predominate. The fossils from the lower beds, Professor M'Coy regards as rather belonging to the Upper Eocene.

"Between Cape Otway and Moonlight Head, only a few patches of Miocene strata occur, showing the enormous denudation to which this coast has been subjected.

"The cliffs at Cape Otway (fig. 2) are occupied by Mesozoic sandstone, overlain by very recent Tertiary calcareous sandstone; but about a mile and a half west of the Cape, the carbonaceous rocks terminate, and we immediately have a small outcrop of Miocene, which consists of dark slate-coloured stiff clay (*g*), abounding in fossils, especially two species of *Turritella*, which may be collected in any quantity. The fossils from here are labelled No. 1. These beds occupy the base of the cliff, and can only be traced for a few chains; they may be referred to the Lower Miocene series.

Fig. 2.—*Sketch Section of the Coast from Castle Cove to near Cape Otway.*



a. *Tæniopteris*-sandstones. *b*. Irregularly stratified yellow calcareous sandstones. *c*. Thin beds of calcareous clay and limestone. *d*. Soft yellow limestone. *e*. Soft calcareous clay beds. *f*. Black argillaceous bed containing leaves. *g*. Dark slate-coloured clay. *h*. Brown sand. *i*. Ferruginous clays and rounded quartz-drift.

[The following Madreporaria have been obtained from No. 1.

Flabellum distinctum, *Edw. & H.*	Deltocyathus italicus, *Edw. & H.*, var.
Conotrochus M'Coyi, *Duncan.*	Balanophyllia cylindrica, *Michel.*, var.]

"Some of the banks around the Aire marsh are composed of soft calcareous clay, with beds of hard coralline limestone, almost wholly made up of comminuted echini-spines and polyzoa; here are also some very ferruginous beds of sandstone containing fossils. These beds may be referred to the lower part of the upper beds, or the upper part of the middle beds of the Spring-Creek series. The fossils collected are labelled No. 12. [No Madreporaria.]

"We next find Miocene occupying the base of the cliffs, about a mile and a half west of the mouth of the Aire river. Here occurs a bed seventeen feet thick (*f*), containing fossil leaves, labelled No. 2. This bed is exactly similar in appearance to those composing the cliffs, which are more than 200 feet high, about a mile east of Point Addis. It consists of a dark, almost black, argillaceous clay, containing crystals of selenite, and having the crevices filled with a yellow substance similar to that found in the Point-Addis beds, which was analyzed and determined by Mr. Daintree to be basic sulphate of iron, the analysis of which is given in his report above alluded to. A few feet below high-water mark this bed rests on dark clay, with fossils similar to that first mentioned, near Cape Otway. These beds dip to the west; but for a little more than a quarter of a mile they are so covered up by the fallen masses of the more recent tertiary sandstone that their sequence cannot be traced; then we get upper beds of the middle series, composed almost entirely of polyzoa, and containing many fossils, a large kind of *Pecten* predominating. Here a fossil seal's tooth was found, the only one, I believe, as yet discovered in the miocene strata in this colony. Professor M'Coy regards this seal's tooth as belonging to the same species as those found in the miocene strata in Malta—which is a very interesting fact. These fossils are labelled Nos. 3 and 4 [and contain the following Madreporaria:—

Flabellum gambierense, *Duncan.*	Balanophyllia campanulata, *Duncan.*
—— distinctum, *Edw. & H.*	Amphihelia incrustans, *Duncan.*
Placotrochus elongatus, *Duncan.*	Balanophyllia Selwyni, *Duncan.*]

"The beds here dip to the west, but in a short distance they rise to Castle Cove, where they are seen resting against the Carbonaceous sandstones (*c*), and dipping at rather a high angle (of about 30°); they consist alternately of soft calcareous clays, and hard thin beds of limestone. Here I obtained very fine specimens of *Terebratulæ*, labelled No. 5.

"The only other patch of Miocene, I believe, on the south side of the coast-range, occurs between the mouth of the Joanna river and Browne's Creek; this is chiefly hard yellow limestone, containing, besides a small species of *Serpula*, very few fossils: the beds dip westerly and evidently belong to the Upper Miocene. The remarkable difference in the lithological character and in the prevailing fossils of these outliers, renders it a matter of difficulty to determine their relations correctly.

"From Moonlight Head to the mouth of the Gellibrand river a very peculiar suite of beds occur. The fossils they contain are evidently Miocene; but, with the exception of being very similar in composition to the leaf-bed occurring between the Aire river and Castle Cove, and also to the beds composing the cliffs about a mile east of Point Addis, they appear to have no equivalents on any other portion of the coast. About a quarter of a mile east of the mouth of the Gellibrand, these beds terminate abruptly, with Pliocene Tertiary resting on and against them. From this point they gradually rise to the eastward, at an angle of about 10°, for about two and a half miles, when they rest horizontally, or nearly so, on the Mesozoic sandstones; thence they continue, with slight undulations, along the coast to the east. The following section, shown in the cliffs from near the Gellibrand river for about two and a half miles eastward, will, I think, give approximately the thickness of these beds.

"Commencing at sea-level we have:—(1st) 45 feet greyish-brown Carbonaceous sandstone, showing false bedding, and containing hard concretionary nodules and fragments of carbonized wood; (2nd) 50 feet of thin ferruginous sandy beds, with small rounded quartz pebbles, the uppermost beds containing fossils, principally *Cucullæa*, *Cytherea*, and *Nautilus*, labelled No. 6; (3rd) 125 feet of nearly black argillaceous beds, containing a few rounded quartz pebbles sparingly interspersed. Crevices in these beds contain the same yellow basic sulphate of iron previously mentioned. In the middle portion of these beds a few fossils are found, chiefly a species of *Petraia*, numbers of a small *Turritella*, aggregated in patches, and a few sharks' teeth, labelled No. 7. [The *Petraia* above mentioned is *Trochocyathus meridionalis*, Duncan, which is accompanied by *Trochocyathus Victoriæ* and *Cycloseris tenuis*, Duncan.] These fossils occur chiefly in a very hard stratum, the hardness of which alone distinguishes it from the softer beds of similar colour with which it is interstratified. (4th) 35 feet of yellow and red ferruginous sandy strata without fossils; (5th) 40 feet of black beds similar to those just described, with the exception that they apparently contain no fossil shells; but wherever you examine them, numerous small branching markings, like Algæ, are found. Specimens obtained, labelled No. 8. The same is observed in all the black beds of this section; also in those between the Aire river and Castle Cove, and in the strata before referred to, about a mile east of Point Addis. Above this we get white, yellow, and red sandy clay, passing up into rounded quartz-pebble drift, probably Pliocene, together about 50 feet. Total thickness from (1st) to (5th) inclusive, about 250 feet. West of the Gellibrand the miocene strata are of an entirely different character, and occupy a very wide area. They occur in the cliffs along the coast for nearly forty miles, and extend north nearly to Camperdown, where they pass under the basalt. For thirty chains from the mouth of the Gellibrand the cliffs are entirely composed of Postpliocene tertiary sandstone; the Miocene beds dipping to the east then commence. A section ten chains further along the coast gives, above sea-level:—

7 feet blue sandy clay, with a few small quartz pebbles scattered through it, and no fossils; 20 feet yellow, red, and grey sandy clay, with no fossils; total 27 feet. Above this, 100 feet Postpliocene calcareous sandstone. About ten chains further west, we find upper Miocene beds full of fossils, consisting of hard, sandy ironstone, about 4 feet in thickness, resting on a bed of ferruginous pebble conglomerate; this, again, rests on a loose ferruginous sandy bed, at high-water mark. The most abundant fossils of the upper bed are a large *Pecten* and the large branching *Cellepora gambierensis*. The pebbles of the conglomerate consist of rolled fragments of Miocene clay, containing fossils; these are mingled with broken-up fragments of fossils and loose saud. This is the only pebble-conglomerate I have seen in the Miocene strata. Unfortunately it could not be traced beyond this point, owing to the fallen masses of the more recent Tertiary sandstone. A little further to the west we come on to a dark slate-coloured stiff clay, very rich in fossils, chiefly univalves. Among the principal ones are very fine specimens of *Cypræa*, *Voluta*, *Fusus*, *Pleurotoma*, *Cerithium*, &c.; these fossils I have labelled No. 9 [see List of Corals, No. 9 p. 312]. A section about three miles west of the Gellibrand affords, above high-water mark:—40 feet dark blue stiff clay, the same as that just mentioned, abounding in fossils; 32 feet rather hard yellowish calcareous clay, containing very few fossils; above this about 75 feet Postpliocene calcareous sandstone. This section is taken nearly at the apex of an anticlinal curve of the Miocene strata, which now dip N.W. at 5° for nearly a mile, when they become nearly horizontal, and are seen to be about 100 feet thick, with 20 feet more or less of Pliocene red clay, resting unconformably on them. These beds evidently belong to the Lower Miocene series. They very much resemble, both in their composition and the character of their fossils, the strata composing the cliff in the Orphan-Asylum Reserve, at Fyan's Ford, near Geelong. From here the strata gently undulate until within a short distance of Curdie's Inlet, when they dip to the west and disappear at sea-level. A section at the mouth of a creek about a mile west of the Sherbrook river gives, above sea-level:—6 feet hard yellow limestone, containing very few fossils; 30 feet bluish clay, rich in fossils; 54 feet yellow calcareous clay with fossils; 10 to 15 feet Pliocene red sandy clay. The fossils from these beds, labelled No. 10, which may be classed as belonging to the lower portion of the middle series, consist chiefly of bivalves. At Port Campbell the cliffs are principally composed of beds of yellow sandy limestone, and yellowish-white calcareous clay, which dip S.W. at 5°; they contain very few fossils. The uniformity in the colour of these beds, and the dim traces of stratification, render it difficult to ascertain the thickness of each bed. They exhibit numerous 'faults' in the cliff-sections; in the short distance of a mile I observed five or six of them.

"The cliffs at the mouth of Curdie's Inlet are only from thirty to forty feet high, composed entirely of a soft yellow limestone, containing very few fossils, excepting two or three small species of

Terebratula and *Spatangus Forbesii*. This limestone appears to rest slightly unconformably on the underlying calcareous clays; for where a section of both is obtained, the former is seen filling up small hollows worn out in the upper beds of the latter. About a mile west of Curdie's Inlet the clay-beds again appear, and rise at a low angle to the west for a short distance, when they gently undulate, until within a few miles of Warrnambool, when they again disappear at sea-level, and the cliffs to the west become entirely occupied by the Postpliocene calcareous sandstone.

"On Curdie's Creek, about ten miles south of Camperdown, we find calcareous clays and limestones similar to those seen along the coast; they contain a few fossils, and are seen passing under the basalt. It is very evident that this formation is continuous, southward, to the coast, with the higher portions of the intervening hills, covered more or less with Pliocene red sandy clay, and concretionary sandy ironstone. This information I obtained from Mr. Scott, District Surveyor, and Dr. Curdie, of Camperdown, who kindly showed me specimens of fossils, &c., collected by them during their tours across this country to the coast."

III. List of the Species of Fossil Madreporaria.

Suborder ZOANTHARIA SCLERODERMATA. (Madreporaria.)

Section *MADREPORARIA APOROSA*.

Family Turbinolidæ.

Subfamily *Caryophyllinæ*.

1. Caryophyllia viola, *Woods & Duncan*. Hamilton tertiaries, Violet Creek.
2. Trochocyathus meridionalis, *Duncan*. No. 7, 2½ miles east of river Gellibrand.
3. —— Victoriæ, *Duncan*, and 1 var. No. 7, 2½ miles east of river Gellibrand.
4. Deltocyathus italicus, *Edw. & H.*, var. No. 1, 1½ mile west of Cape Otway.

Subfamily *Turbinoliaceæ*.

5. Sphenotrochus australis, *Duncan*. Hamilton tertiaries.
6. —— excisus, *Duncan*. Hamilton tertiaries.
7. Conotrochus M'Coyi, *Duncan*. No. 1, 1½ mile west of Cape Otway.
8. —— typus, *Seguenza*. No. 9, 3 miles west of the Gellibrand river.
9. Flabellum Victoriæ, *Duncan*. Hamilton tertiaries, Muddy Creek.
10. —— gambierense, *Duncan*. Mt. Gambier and No. 4 clay, Cape Otway.
11. —— Candeanum, *Edw. & H.* Murray tertiaries, and No. 9, 3 miles west of Gellibrand river.
12. —— distinctum, *Edw. & H.* No. 1 and No. 4.
13. Placotrochus elongatus, *Duncan*. Hamilton tertiaries, Muddy Creek, and No. 4.
14. —— deltoideus, *Duncan*. Hamilton tertiaries, Muddy Creek, and No. 9.

Family Oculinidæ.

Division *Oculinaceæ.*

15. Amphihelia incrustans, *Duncan.* No. 3, Upper Coralline beds, Cape Otway.

Family Fungidæ.

Subfamily *Lophoserinæ.*

16. Palæoseris Woodsi, *Duncan.* Hamilton tertiaries, Muddy Creek.
17. Cycloseris tenuis, *Duncan.* No. 7, 2 miles east of the river Gellibrand.

Family Astræidæ.

Subfamily *Eusmilinæ.*

Division *Trochosmiliaceæ.*

18. Conosmilia elegans, *Duncan.* Geelong tertiaries.
19. —— anomala, *Duncan.* Hamilton tertiaries.
20. —— striata, *Duncan.* Geelong tertiaries.
21. —— lituolus, *Duncan.* No. 9, 3 miles west of the river Gellibrand.

Division *Lithophylliaceæ.*

22. Antillia lens, *Duncan.* Hamilton tertiaries.

Section *MADREPORARIA PERFORATA.*

Family Madeporidæ.

Subfamily *Eupsamminæ.*

23. Balanophyllia campanulata, *Duncan,* No. 4.
24. —— seminuda, *Duncan.* Hamilton tertiaries.
25. —— armata, *Duncan.* Hamilton tertiaries.
26. —— tubuliformis, *Duncan.* Hamilton tertiaries.
27. —— fragilis, *Duncan.* Hamilton tertiaries.
28. —— australiensis, *Duncan.* Hamilton tertiaries.
29. —— Selwyni, *Duncan.* No 3, Upper coral-beds.
30. —— cylindrica, *Mich.*, var. No. 1, 1½ mile west of Cape Otway.
31. —— Ulrichi. *Duncan.* No. 1, 1½ mile west of Cape Otway.

IV. Description of the Species.

1. Caryophyllia viola, Duncan and Woods. Plate XIX. fig. 1.
Turbinolia viola, Woods, MS.

The coral is cuneiform and very much compressed at the base, which is rounded inferiorly. The calice is elliptical and shallow. The septa are delicate; the principal are exsert and rounded, having large lateral spiny granules. There are six systems of septa, and four cycles. The first three orders are nearly equal; but the septa of the fourth and fifth orders are small, curve towards and touch the tertiary. The pali are tall rounded lobes on the tertiary septa; they are stout, larger than the end of the septa, and are sparsely granular. The columella is long and papillary. The costæ are visible to the base, are slightly wavy in their course, are separated by di-

stinct grooves, and are of different lengths, those of the higher orders joining the others, which reach to the base. All are visibly crenulate and faintly granular.

In form the coral resembles a *Sphenotrochus*; the papillæ on the columella resemble those of *Brachycyathus*; the single row of pali and the distinct costæ determine it to be one of the *Caryophylliæ*; but the absence of an epitheca is remarkable. It is a very beautiful form, and, without its calice, would be taken for an Eocene Turbinolian.

Height $\frac{4}{10}$ inch. Length of calice $\frac{3}{10}$ inch; width of calice $\frac{2}{10}$ inch.

Locality. Violet Creek, near Muddy Creek, South Australia.

2. Trochocyathus meridionalis, n. sp. Plate XIX. fig. 2.

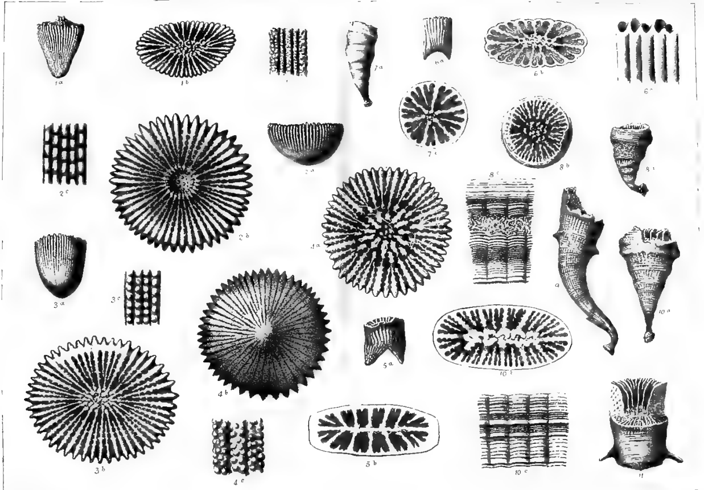
The corallum is short and hemispheroidal in shape, marked externally by subequal costæ and a depression at the base, small and circular in outline. The costæ are separated by distinct intercostal spaces, are very prominent at the calicular margin, and faintly marked with wavy swellings, and their external surface near the base has a row of rounded granules. The primary and secondary are slightly larger than the tertiary, and the higher orders are smaller than the latter. The calice is circular in outline, and shallow. The septa are distinct, unequal, distant, and smaller than the costæ. They are broad externally and exsert, but they soon become narrow, granular laterally, and depressed below the calicular margin. There are four cycles, in six systems: the primary are the largest, and are connected with the largest and most prominent costæ; the secondary are smaller; and the smallest septa, *i. e.* those of the fourth and fifth orders, only unite with the tertiary far inwards. The granules are large, and appear to increase in size towards the columella. There are pali before all the septa except those of the last cycle; and the upper edges of the septa pass upwards and inwards to reach the pali, which are small, long, and granular. The tertiary pali are more external than the others; and all are united laterally by a spongy tissue, so as to form a ring higher than the septa in the body of the calice. The ring occupies much space, forms the outside of the columella; and within the ring is a deep fossula, at the bottom of which the hard and flat centre of the columella is seen.

Height of corallum $\frac{3}{10}$ inch. Breadth of calice $\frac{5}{10}$ inch.

Locality No. 7, $2\frac{1}{4}$ miles east of the river Gellibrand.

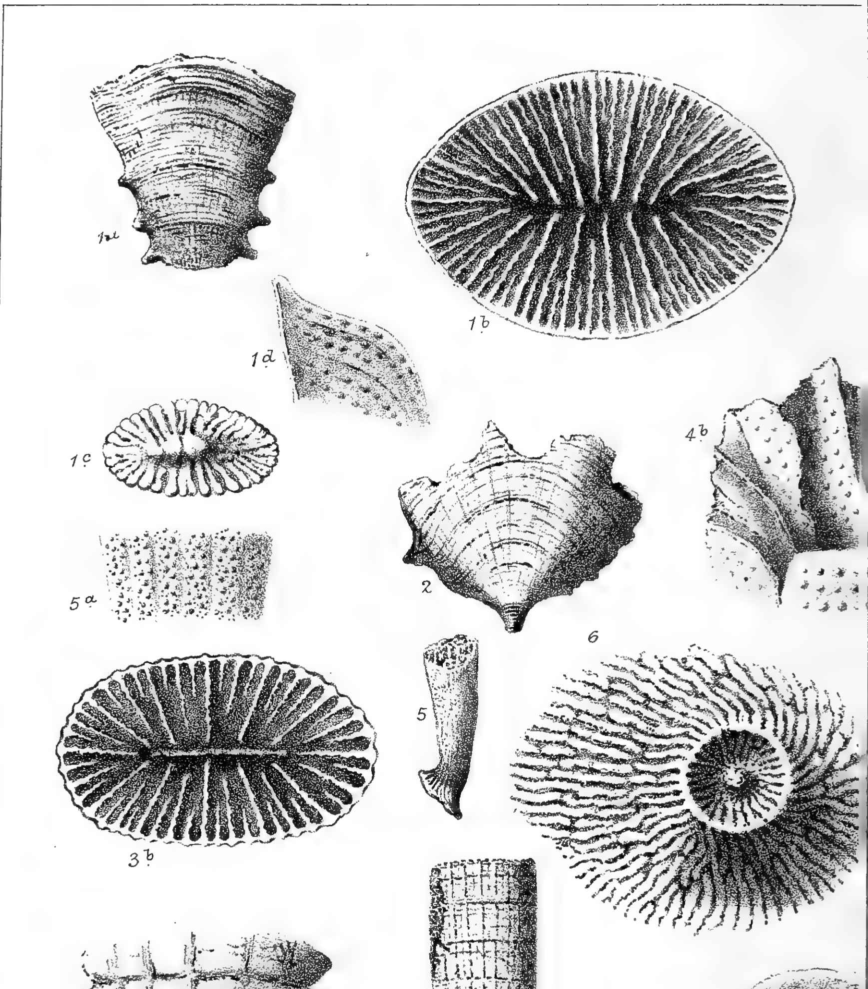
3. Trochocyathus Victoriæ, n. sp. Plate XIX. fig. 3.

The corallum is subturbinate and compressed. The base is elongate and nearly in the shape of a ridge. The calice is elliptical in shape, and shallow. The costæ are slightly waved, distinct, subequal, prominent, rounded, and ornamented on the free surface by circular disks with a central boss-like swelling, or by moniliform swellings covered with a pellucid structure, which, when worn, represents the outside of the disk. They are slightly granular laterally. The calicular margin is broad, and the wall is stout. The septa are



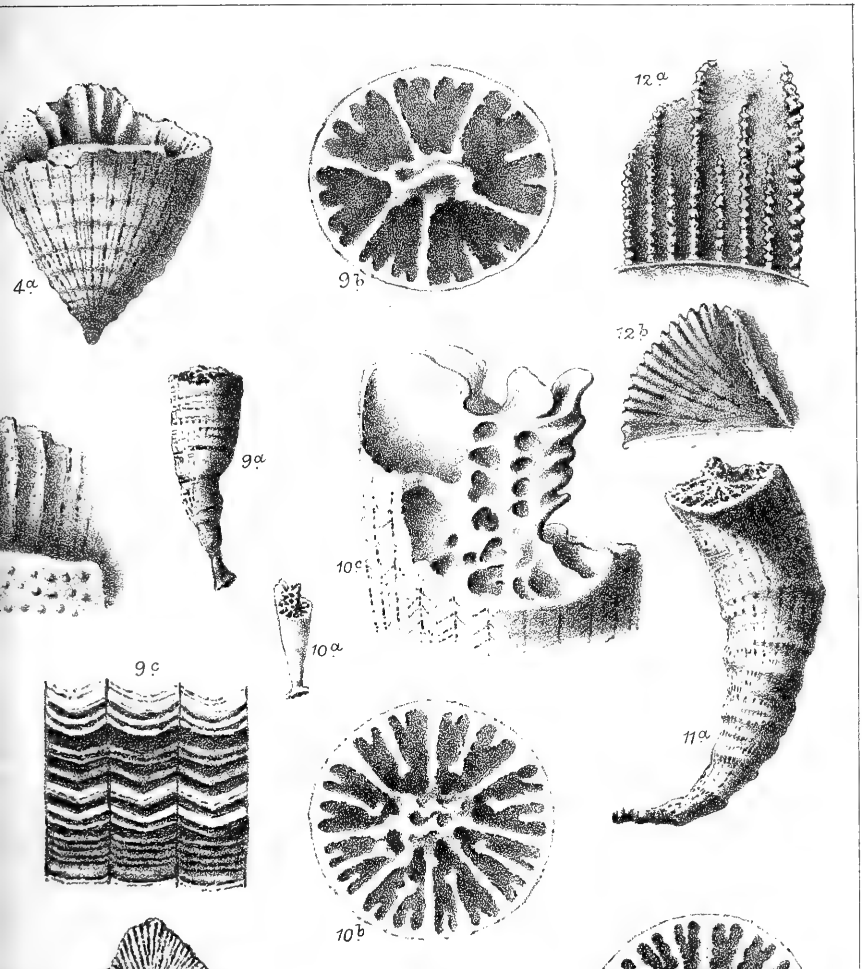
G. R. de Wilde del. et lith.

AUSTRALIAN TERTIARY CORALS



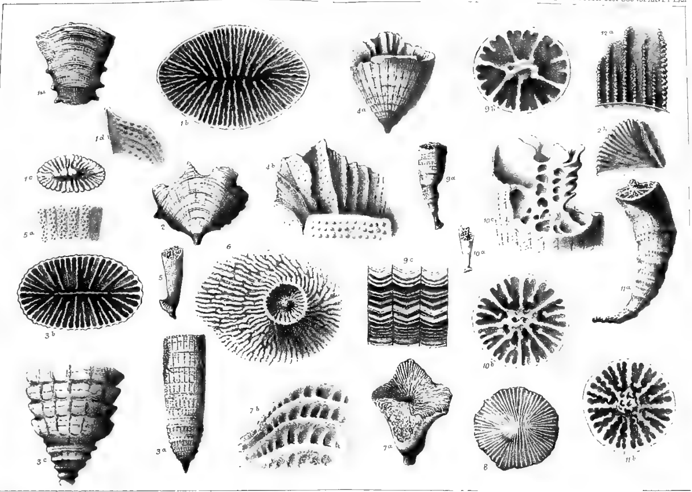
G.R. De Wilde del. et lith.

AUSTRALIAN T



W. West imp.

TIARY CORALS.



G. R. De Wilde del. et lith.

AUSTRALIAN TERTIARY CORALS

smaller than the costæ, and rather exsert, but soon become thin, granular laterally and rather wavy in their course; they are long, wide apart, and unequal; those of the higher orders are long, and turned towards the tertiary near the columella; there are four cycles of septa, in six systems. The pali are slightly broader than the septal ends, and are long and granular. They are before all the septa except those of the fourth and fifth orders. The columella is essential, spongy, and small.

Height of the corallum $\frac{4}{10}$ inch. Length of calice $\frac{10}{30}$ inch. Breadth $\frac{8}{30}$ inch.

Locality. No. 7, $2\frac{1}{4}$ miles east of the river Gellibrand.

Variety. A variety whose corallum is taller, and whose base is filled up with sclerenchyma, has larger costæ and more distinct ornamentation. When worn these fossils present very distinct costæ, with an uneven free surface. They occur in a kind of dark shale, and are found in numbers together.

4. Deltocyathus italicus, var. australiensis. Plate XIX. fig. 4.

The corallum is in the shape of a very short cone. The costæ are very distinct from the base to the calicular margin; they are nearly equal in breadth; but there are twelve which are longer than the others, and straight. Those next in size bifurcate, and the smallest are placed between the costæ resulting from the bifurcation. All are rounded, intensely and distinctly granular externally and laterally, and separated by deep intercostal spaces. The calice is circular in outline, rather convex; and the costæ run into septa without the wall being seen. The septa are unequal in length, but very equal in thickness; they are simply granular, stout, and somewhat arched. There are four cycles, in six systems. The pali are very distinct, granular, and broad; they are placed before the secondary and tertiary cycles. Those before the secondary septa are nearest the columella; and those before the tertiary do not pass in a right line to the columella, but to the secondary pali. The columella is papillary.

Height of the corallum $\frac{1}{10}$ inch. Breadth of the calice $\frac{1}{5}$ inch.

Locality. $1\frac{1}{2}$ mile west of Cape Otway.

The typical *Deltocyathus* is found at Tortona, in a miocene deposit; it is very closely allied to the Australian form, which has granular costæ.

5. Sphenotrochus australis, Duncan. Plate XIX. fig. 5.

The coral is very compressed, especially inferiorly, where, on either side of the centre of the base, a process passes downwards, giving it a "fishtail" appearance. At the calice the compression is less, but the great axis is at least twice the length of the smaller. The coral is longer than broad. The costæ are broad, somewhat wavy, and separated by well-marked lines: those of the inferior appendages arise from the extremities of the processes, and pass upwards and inwards; and the lateral costæ, wavy below, become straight above. All are plain. The wall is much thicker at the

ends of the long axis than elsewhere (in sections). The calice is not shallow, is elliptical, and presents, deeply seated, a long lamellar columella, which is joined to the primary and secondary septa by processes. The septa are well developed and plain; they are not exsert, but pass straight downwards and inwards towards the columella; they do not correspond to the costæ, but to the intervals between the costæ, and they number thirty-two. There are three cycles, with the orders of a fourth, in two systems.

Height $\frac{1}{2}$ inch. Breadth $\frac{1}{4}$ inch. Small diameter, halfway, $\frac{1}{10}$ inch.

Locality. Hamilton, Victoria, South Australia.

6. Sphenotrochus excicus, Duncan. Plate XIX. fig. 6.

The coral is generally much compressed, especially inferiorly, where two lateral processes give a notched or emarginate appearance to the base. Superiorly the relation of the long to the short axis is at least as 2 to 1. The coral is short and broad; the base is nearly as wide as the calice is long. The costæ are large and plain, and are separated by well-marked lines: the costæ of the appendices are the largest; they pass upwards to the calice, and all are more or less wavy, the central widening out near the calicular margin. The calice is shallow and elliptical. The columella is not long, and, from being joined to the primary and secondary septa by processes which are rounded above, is confused in its appearance. The septa are in six systems of three cycles; they are wider at the wall than elsewhere, and granular, and those of the third cycle are much smaller than the others. All the septa correspond to the depressions between the costæ.

Height $\frac{1}{4}$ inch. Breadth $\frac{2}{10}$ inch.

Locality. Hamilton, Victoria, South Australia.

7. Conotrochus M'Coyi, n. sp. Plate XIX. fig. 7.

The corallum is small, claviform, straight, and marked with strong transverse ridges of epitheca. The calice is circular in outline, and the margin is rather stout. The septa are unequal; there are three cycles, in six systems; and the primary, which reach the columella, are very stout, slightly arched, and faintly granular. The secondary septa are smaller than the primary, and they occasionally reach the columella; the tertiary septa are either rudimentary or only faintly seen. The columella is stout, papillary, essential, and projecting.

Height of the corallum $\frac{1}{2}$ inch. Breadth of the calice about $\frac{1}{5}$ inch.

Locality. 1–$1\frac{1}{2}$ mile west of Cape Otway.

8. Conotrochus typus, Seguenza, var. australiensis. Plate XIX. fig. 8. Segu. Disqu. Pal. intorno ai Corall. Foss., Mem. Acad. Turin, tom. xxi. p. 478.

The corallum is small, cylindro-conical, curved and pedicellate. The epitheca is strong, and ridged transversely, and reaches to the calicular margin; it is marked with wavy lines transversely, and

with elevations longitudinally. The calice is circular. The septa are not exsert, and are unequal, short, not very straight, granular and distant; the cyclical arrangement is very irregular, and there are three cycles in some systems, and part of a fourth in others. The septa are alternately large and small, and there are twenty-eight of them. The columella is large, and consists of several (twelve) irregularly shaped papillose projections.

Height of the corallum $\frac{4}{10}$ inch. Breadth of the calice $\frac{2}{10}$ inch.

Locality. No 9, 3 miles west of the river Gellibrand.

9. Flabellum Victoriæ, Duncan. Plate XIX. fig. 11.

The coral presents a large basilar erosion, the result of the breaking-off of the peduncle: it has a sharp lateral spine on either side, which projects outwards and downwards, and which is situate immediately above the erosion. The coral is tall, compressed more below than above; its sides are slightly concave; and it is furnished with an epitheca which has faint transverse markings. The sides of the coral, where they are produced towards the attachment, would form an angle of about 20°; they are rounded off, and only present the spine already noticed. The calice is elliptical; the plane of the smaller axis is slightly higher than that of the larger; the fossa is shallow, but centrally deep, narrow, and long, and the wall is thin. The septa are delicate, not exsert, are very slightly rounded, marked by large granules in series, and unequal; there are four cycles, in six systems, the primary and secondary septa being equal. There is no columella. The intercostal spaces are developed into rounded ridges, and the septa are continuous with them.

Height $\frac{6}{10}$ inch. Length of calice $\frac{5}{10}$ inch. Breadth of calice $\frac{4}{10}$ inch.

Locality. Muddy Creek, South Australia.

10. Flabellum distinctum, Edw. & H. Plate XX. fig. 2.

The corallum is much compressed. The lateral costæ are slightly convex, not almost horizontal, but slightly ascending, and furnished with strong crests inferiorly. The principal costæ are distinct and broad, but very slightly prominent. The calice has a slightly convex margin; the axes are as 100 to 240; the summits of the large axis are rounded, and are situated at the upper third of the corallum; the fossule is narrow and very deep; and the columella is quite rudimentary or does not exist. There are six systems of septa, and six cycles, in perfect specimens.

Localities. No 1, 1½ mile west of Cape Otway, and No. 4, clay beneath "Coralline beds," Cape Otway. Recent in the Red Sea and Japan.

11. Flabellum gambierense, Duncan. Plate XIX. figs. 9 & 10.

The coral is tall, slightly or decidedly curved, has a long tapering pedicel, concave sides, and often small spines nearer the calice than the pedicel; it is compressed, has a strong epitheca, whose folds are arched and finely linear, and a calice oval-elliptical in shape. The

septa are in six systems of four cycles: the primary and secondary are equal, stout, granular, and enlarged internally, where their ends form a rudimentary parietal columella; the other septa are smaller and granular. The costæ are represented by depressions, and the intercostal spaces by rounded elevations, which are marked by chevron markings of the epitheca. The septa are continuous with the depressions between the "intercostal spaces," which may be regarded more or less as costæ.

Height of the coral $\frac{8}{10}$ inch. Length of calice $\frac{4}{10}$ inch. Width of calice $\frac{3}{10}$ inch.

Localities. Tertiaries of Mount Gambier, South Australia, and No. 4, clay beneath "Coralline beds," near Cape Otway, Victoria, S. Australia.

12. Flabellum Candeanum, Edw. & H. Plate XX. fig. 1.

Locality. Murray Tertiaries. No. 9, 3 miles west of the river Gellibrand

13. Placotrochus elongatus, Duncan. Plate XX. fig. 3.

The coral is very tall in relation to its breadth, straight, greatly compressed, especially inferiorly, finely pedicellate and cuneiform. The sides are rounded, and slightly swollen out here and there, and form an angle of about 15°–20°, or are sharp and slightly spined; but the spines do not project much beyond the epitheca (in old specimens). The anterior and posterior surfaces are flat. The calice is small, elliptical, and rounded at the sides; it has slightly exsert septa, which are rounded, thin, delicate, unequal, and in six systems of four cycles. The fossa is central, shallow, and long; the columella projects from the bottom of it as a distinct, straight lamella. The columella is stout in the body of the coral, and is thinner at its free edge; laterally it is marked by distinct papillæ, which mark the junction of the principal septa; and it is "essential." The lamellæ of the septa are delicate, highly granular, and are often wavy at the inner margin. The smaller axis of the calice is slightly higher than the longer. The costæ are faintly marked, or distinct and linear. The epitheca is in strong curved folds, often as festoons between the costæ.

Height $\frac{8}{10}$ inch. Length of calice $\frac{3}{10}$ inch. Breadth of calice $\frac{2}{10}$ inch.

Localities. Muddy Creek, South Australia, and No. 4, clay beneath "Coralline beds," South Australia.

14. Placotrochus deltoideus, Duncan. Plate XX. fig. 4.

The corallum is deltoid, finely pedicellate inferiorly, and compressed. Superiorly the calice is wide and long. The costæ are moderately distinct. The epitheca is strong, and presents arched ridges, the costæ being often chevroned beneath it. The columella is long, sharp, thin, and faintly papillate. The septa are not exsert, are feebly arched and delicate, granular, and their internal

margin is often wavy. There are six systems, and five incomplete cycles. The lateral crests form an angle of about 60°.

Height of coral 1 inch. Length of calice $\frac{9}{10}$ inch.

Locality. Muddy Creek, South Australia. No. 9, 3 miles west of the river Gellibrand.

Variety *bursarius* with the lateral crests forming convex prominences.

PALÆOSERIS, gen. nov.

This genus forms part of that named and described by Milne-Edwards and Jules Haime as *Palæocyclus*, and it is proposed for the reception of *Trochoseris Woodsi*, nobis (Ann. Mag. Nat. Hist. Sept. 1864). There was some doubt concerning the genus of *T. Woodsi* when the species was described, because its anatomical details clearly pointed out *Palæocyclus* as the genus under which it should be arranged. But *Palæocyclus* is a Silurian genus, the only one of the Fungidæ in the Palæozoic coral-faunas. A careful examination of the species described under the generic term *Palæocyclus* was undertaken (see Phil. Trans. Roy. Soc. 1867); and I found that they could not be admitted amongst the Fungidæ at all, as they did not possess synapticulæ and did possess tabulæ. The *Palæocycli* of Edwards and Haime are truly palæozoic forms, and are *Cyathophyllidæ*. An examination of the species *Woodsi* decided my referring it no longer to *Trochoseris* but to a genus which would replace *Palæocyclus* more in name than in minute anatomy.

The genus must be classified with the Lophoserinæ.

The corallum is simple, turbinate, and pedicellate. The septa are numerous. The epitheca is complete and dense, covering the costæ. The columella is rudimentary.

15. PALÆOSERIS WOODSI, Duncan. Plate XX. Fig. 7.
Trochoseris Woodsi, Duncan.

The corallum is fixed by a small pedicel, and is cylindro-conical and turbinate in shape. The calice is widely open, circular, and shallow; the margin is thin. The septa are not exsert, but are delicate, crowded and rather subequal; there are six systems, and five cycles, with the half of a sixth, in each system. The smaller septa generally join the larger; and these reach the central fossula. The laminæ are marked laterally by synapticulæ.

Height $\frac{7}{10}$ inch. Breadth of calice $\frac{6}{10}$ inch.

Locality. Muddy Creek, South Australia.

16. CYCLOSERIS TENUIS, n. sp. Plate XX. fig. 8.

The corallum is circular in outline and very thin; it is slightly convex centrally, where there is a shallow elongated fossule; and there is a decided concavity inferiorly, marked with numerous costæ. The septa are distinct, distant, very slightly marked with rounded dentations; and there five cycles, incomplete and in six systems.

Height $\frac{2}{10}$ inch. Breadth $\frac{1}{2}$ inch.

Locality. No. 7, $2\frac{1}{2}$ miles east of the river Gellibrand, Victoria, South Australia.

17. Balanophyllia campanulata, n. sp. Plate XXI. Fig. 1.

The corallum is pedicellate, has a slight constriction immediately above the small base, and expands regularly into an elongate bell-shape. The epitheca exists inferiorly; but it is very delicate, and permits the flat costæ to be distinguished. The calice is elliptical, and the margin is slightly everted; the wall is moderately developed. The columella is large, long, spongy, and prominent. The septa are stout: there are four cycles; and the septa of the fourth and fifth orders unite with the tertiary midway between the wall and the columella. The tertiary septa, after the junction with the others, are as large as the primary and secondary septa. The laminæ are granular. The costæ, where uncovered, are separated by distinct intercostal spaces with numerous foramina; they are slightly unequal, and have both granulations and foramina on their flat external surface. There are rarely more than two rows of granules; and they are scarce.

Height of the corallum $\frac{8}{10}$ inch. Breadth of the calice $\frac{5}{10}$ inch.

Locality. No. 4, clay beneath "Coralline beds," near Cape Otway. It is associated with *Trigonia semiundulata.*

18. Balanophyllia seminuda, n. sp. Plate XXI. fig. 2.

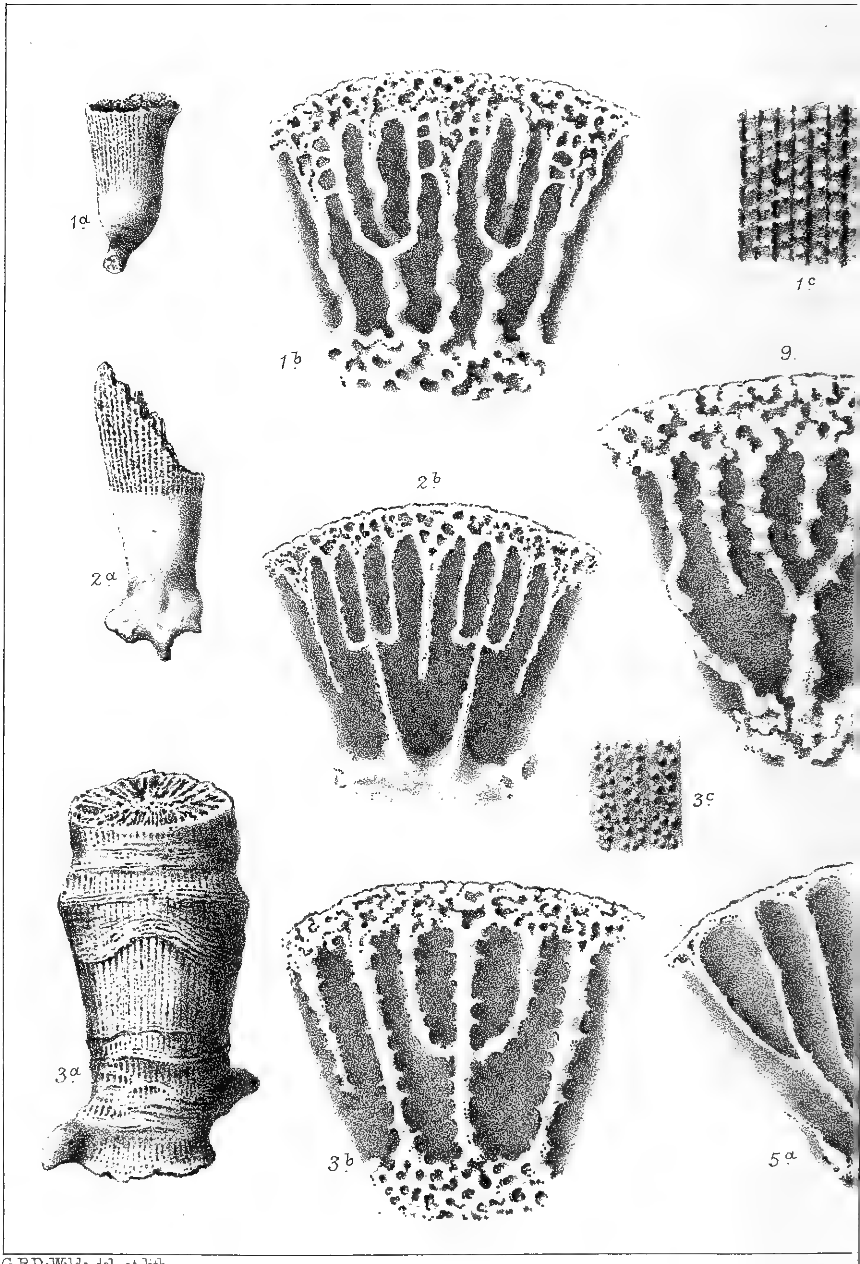
The corallum has a wide base, with a constriction immediately above it, and is cylindrical, but slightly wider at the calice than elsewhere. The epitheca is very dense for half the distance up the corallum, and is wanting elsewhere. The costæ, invisible below, are distinct where the epitheca does not exist above; they are formed by vermiculate projections. The calice is circular in outline; its margin is thin, except at the origin of the primary and secondary septa, where it is thick and cellular; and its fossa is very deep. The septa are unequal, exsert, curved above, and more or less vertical at their inner edge; they are marked with ridges which are directed inwards and upwards, and with endothecal ridges crossing the first kind. The primary septa are stout and very exsert, and the secondary septa are smaller and less prominent; the tertiary septa, after their union with those of the fourth cycle, are very stout, and reach the columella; the septa of the fourth and fifth orders join the tertiary about halfway to the columella. The columella is small and spongy, and is situated very deeply in the fossa.

Height of the corallum $\frac{8}{10}$ inch. Breadth of the calice $\frac{3}{10}$ inch.

Locality. Hamilton Tertiaries, Victoria, South Australia.

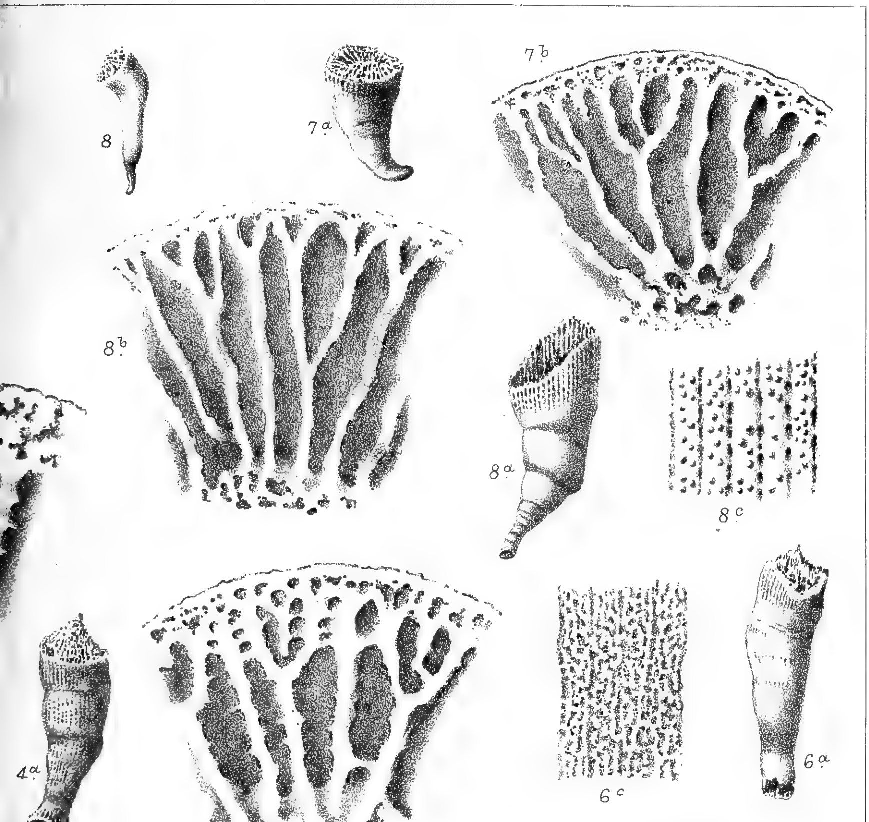
19. Balanophyllia armata, n. sp. Plate XXI. fig. 3.

The corallum is subcylindrical, tall, compressed and armed with a winglike projection immediately above either side of the base; the base is moderately large, and presents evidences of attachment to some substance during life; there is a slight constriction above the base. The epitheca is imperfect, and surrounds the corallum here



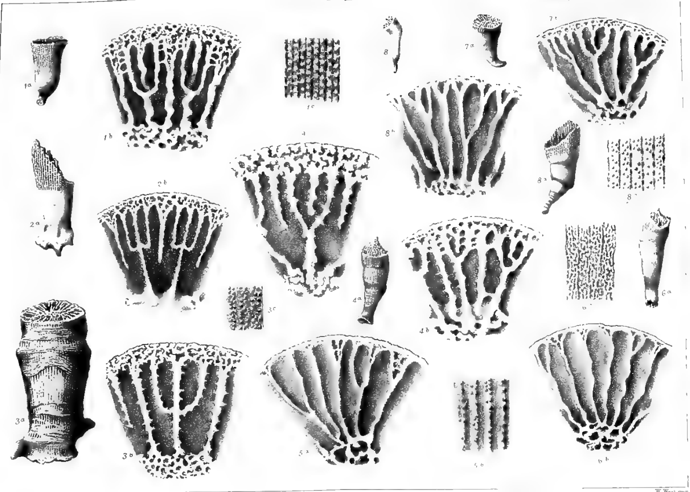
G R.DeWilde del et lith

AUSTRALIAN T



W. West imp.

TIARY CORALS.



G. R. De Wilde del. et lith.

W. West imp.

AUSTRALIAN TERTIARY CORALS

and there in wavy lines. The costæ are distinct, wide, equal, and covered with spiny granulations; they are more or less continued over the small lateral winglike projections. The calice is elliptical in its outline, shallow, and with a sharp, narrow, and slightly cellular margin. The columella is large, long, and spongy. The septa are unequal, not exsert, stout, and granular; there are four cycles of septa in six systems, and there are a few septa of the fifth cycle in some systems. The septa of the first, second, and third orders reach the columella; and those of the higher orders curve towards and meet the tertiary midway between the wall and the columella.

Height of corallum $1\frac{2}{10}$ inch. Breadth of calice $\frac{1}{2}$ inch.

Locality. Hamilton Tertiaries, Victoria, South Australia.

20. Balanophyllia Selwyni, n. sp. Plate XXI. fig. 4.

The corallum is subcylindrical and slightly compressed, and has a large base with a slight constriction above it. The costæ are distinct, flat above and rounded midway and below, finely granular superiorly, and marked with one series of large granules inferiorly. The epitheca is absent. The wall is moderately developed. The columella is large and long. The septa are very stout. There are four cycles of septa, in six systems; and the higher orders unite with the tertiary at about one-fourth of the distance from the wall to the columella. The calice was compressed and elliptical.

Height 1 inch. Greatest length of the calice $\frac{1}{3}$ inch.

Locality. No. 3, Upper "Coralline beds," near Cape Otway, South Australia.

21. Balanophyllia fragilis, n. sp. Plate XXI. fig. 5.

The corallum is long and conico-cylindrical in shape, twisted and curved. The epitheca is quite rudimentary, in the form of slight transverse bands. The costæ are flat and marked with one series of small distinct sharp spiny granules, or with a ridge. The wall is very thin and hardly cellular. The columella is very small. The septa are plain, long, slender and irregular; the higher orders unite with the tertiary close to the wall. There are four cycles, in six systems, the fifth order being occasionally absent. The endotheca is tolerably developed.

Height of corallum $\frac{3}{4}$ inch. Length of calice $\frac{1}{4}$ inch.

Locality. Muddy Creek, Hamilton Tertiaries, South Australia.

22. Balanophyllia australiensis, Duncan. Plate XXI. fig. 6.

The corallum is pedicellate, long, cylindrical, tapering and curved. The calice is elliptical. The fossa is shallow. The septa are not exsert, are thin, marked with arched ridges, and there are four cycles, in six systems, with a few laminæ of the fifth cycle. The higher orders unite with the tertiary close to the wall, which is very thin. The columella is large. The epitheca is scanty, and surrounds the corallum at certain parts only. The costæ are vermiculate, and slightly spinate.

Height of corallum $1\frac{1}{2}$ inch. Length of calice $\frac{4}{10}$ inch.

Locality. Muddy Creek, Hamilton Tertiaries, South Australia.

23. Balanophyllia cylindrica, Michel. sp., variety α. Plate XXI. fig. 7.

The corallum is cylindro-turbinate and curved at the base, which is not pedicellate, but sharp. The calice is large, shallow, and very open. The epitheca is complete and covers the faintly distinguishable costæ. The wall is moderately stout and cellular. The columella is moderately developed. The septa are stout; and there are four cycles, in six systems: the higher orders unite with the tertiary about midway.

Height of corallum $\frac{7}{10}$ inch. Breadth of calice $\frac{4}{10}$ inch.

Locality. No. 1, $1\frac{1}{2}$ mile west of Cape Otway.

Variety β. Corallum more slender and columella larger than in variety α; the same locality.

24. Balanophyllia Ulrichi, n. sp. Plate XXI. fig. 8.

The corallum is cylindro-conical, slightly curved, and has a small peduncle and a large open calice. The epitheca is dense and complete inferiorly; but above, the costæ are uncovered and are well marked, equal, rather prominent, separate, and finely granular. The columella is small. The septa are slender; and there are four cycles, in six systems. The fossa is deep, and the margin thin.

Height of corallum $\frac{6}{10}$ inch. Breadth of calice $\frac{3}{10}$ inch.

Locality. No. 1, $1\frac{1}{2}$ mile west of Cape Otway, South Australia.

25. Balanophyllia tubuliformis, n. sp. Plate XXI. fig. 9.

The corallum is tall, cylindrical, and tubular in shape. There is no epitheca. The costæ are equal, flat, vermiculate, and separated by distinct spaces. The calice is circular in outline, rather less in calibre at the margin than elsewhere, very deep, and it has a wide margin. The wall is stout and cellular. The columella is small, and at the bottom of the deep fossa. The septa are stout, and very granular; and there are four cycles, in six systems. There is a very slight in-bending of the higher orders; and the septal arrangement has very little of the Eupsammian type.

Height of the corallum $\frac{8}{10}$ inch. Breadth of the calice $\frac{3}{10}$ inch.

Locality. Muddy Creek, Hamilton Tertiaries, South Australia.

26. Amphihelia incrustans, n. sp. Plate XX. fig. 6.

The corallum is flat and incrusting, and the calices arise like crateriform processes. The upper surface is irregular and marked with wavy, subequal, bifurcating costæ, which pass upwards on the outside of the calice more or less obliquely. The calice is crateriform; the margin is sharp, and the fossa is shallow. The septa are smaller than the costæ, and not exsert; there are three cycles, in six systems, and a few orders of the fourth cycle. The columella is small and projecting.

Breadth of the calice $\frac{3}{20}$ inch.

Locality. No. 3, Upper "Coralline beds," near Cape Otway.

CONOSMILIA, Duncan.

Coral simple, pedicellate, conical. Columella formed of one or more twisted laminæ, which extend from the base upwards. Endotheca scantily developed. Septa apparently with simple margins, and variable in regard to the number of the primary.

27. CONOSMILIA ELEGANS, Duncan. Plate XX. fig. 5.

The pedicel is large. The costæ, equal, sharp, and prominent at the base, become broad, flat, and granular above, where they are separated by very faint lines. The columella is formed by one twisted lamella, and occupies much space. The septa are in eight systems of three cycles. There are eight primary septa which reach the columella; the secondary are smaller and reach midway; and the tertiary are very small. The septa are nearly plain, are as thick at the columella as at the calicular margin, and appear to arise between the costæ. The calice is nearly circular.

Height $\frac{3}{10}$ inch. Breadth of calice $\frac{1}{10}$ inch.

Locality. Geelong, Victoria, South Australia.

28. CONOSMILIA ANOMALA, Duncan. Plate XX. fig. 10.

The coral is tall in relation to its small pedicellate base. The costæ are not prominent, but are traced by the faint lines which separate them, and by the fine herring-bone pattern which marks each of them. The columella is large and strong, and consists of two twisted riband-shaped laminæ. The septa are in eight systems of three cycles; the laminæ are sparely granular; and the primary are attached to the columella by processes. The secondary are smaller than the primary, and their inner edge is wavy; the tertiary septa are small. The septa arise between the costæ. The endotheca is sparely developed. The wall is very thin. The calice is slightly elliptical.

Height $\frac{6}{10}$ inch. Greatest breadth $\frac{2}{10}$ inch.

Locality. Hamilton, Victoria, South Australia.

29. CONOSMILIA STRIATA, Duncan. Plate XX. fig. 9.

The coral has a very narrow base, and does not expand gradually. The costæ are very broad, have marked lines between them, are very flat, and have wavy transverse markings like those of a pellicular epitheca. Septa in six systems of three cycles; the primary, which are granular, reach the columella, which appears to be formed by one twisted process. The septa arise between the costæ. The calice is more or less elliptical.

Height $\frac{6}{10}$ inch. Greatest breadth $\frac{2}{10}$ inch.

Locality. Geelong, Victoria, South Australia.

30. CONOSMILIA LITUOLUS, n. sp. Plate XX. fig. 11.

The corallum is horn-shaped, long, tapering and doubly curved. The pedicel is small. The body is marked with growth-rings, and the costæ are very feebly developed. The intercostal spaces are in-

distinct and shallow, and are marked feebly by a herring-bone pattern of the pellicular epitheca. The calice is circular in outline, and the wall is very thin. The columella is well-developed, and is essential and fascicular. The septa are in eight systems; and there are three cycles in each system. The marginal ends of the septa correspond to the intercostal spaces. The primary septa are the largest, and reach the columella; the secondary and tertiary are often wavy, and end by an enlargement. The endotheca is moderately developed.

Height 1 inch. Breadth of calice $\frac{3}{10}$ inch.

Locality. No. 9, three miles west of the river Gellibrand, South Australia.

31. Antillia lens, Duncan. Plate XX. fig. 12.

Coral in the shape of a cyclolite *Fungia*; the base is circular in outline, nearly flat, the concavity being very slight. The epitheca is pellicular and faint. The costæ are seen as radiating flat elevations, those corresponding to the smallest septa being the smallest. The margin of the base presents slightly exsert, equal processes, which are the septa. The upper surface of the coral is convex and nearly hemispherical, the depression for a small essential columella, formed by processes from the base and septal ends, being slight. The septa are in six systems of four cycles; the primary and secondary septa are equal, and the tertiary are nearly as large; those of the fourth and fifth orders are somewhat less: all are very convex superiorly, and less so and nearly straight externally. The laminæ are thin, and are very strongly marked by sharp ridges, which, radiating from the basal part of each septum, are more or less parallel, and give at the free margin a laterally dentate appearance. This appearance is less marked in the smaller septa. There is often a paliform process on the larger septa near the columella; and the terminations of the ridges give the dentate character to the free margin of the septa. The endotheca is scanty, stout, and inclined.

Breadth $\frac{3}{10}$ inch. Height $\frac{2}{10}$ inch.

Locality. Hamilton, Victoria, South Australia.

V. Remarks on the Species.

Caryophyllia viola is very unlike any European or American species of the genus. It differs equally from the fossil forms. It has a greater resemblance, as far as shape is concerned, to the *Pleurocyathi* of the German Oligocene than to any other corals; but it is evidently a *Caryophyllia* with a papillary columella and tall pali. The formation of the columella separates it from the other species of the genus; and it exhibits that aberration of unimportant structures which is so frequently observed in Australian Mollusca as well as Radiata. Hitherto no *Caryophylliæ* have been found in the coral-seas between the east coast of Africa and the west coast of America. The species *C. viola* is therefore a very characteristic fossil of a portion of the Cainozoic formation of South Australia.

The *Trochocyathi* are very unlike any other species of the genus in

the development of their costæ. They have not a close affinity with the recent *Trochocyathi* of New Zealand; and the subhemispherical form somewhat resembles the Miocene species of Tortona and India. One of the species is probably the "*Petraia*" mentioned by Mr. Wilkinson. The only living *Trochocyathi* are found off New Zealand. The genus culminated in the Miocene of Europe; and species of it were rare in the West-Indian deposits.

Deltocyathus italicus is a well-marked form, although the genus is hardly worthy to be separated from *Trochocyathus*. The shape and ornamentation of the corals are most beautiful; and they form the prettiest of all the miocene Madreporaria of Europe. Very lately Count Pourtales dredged up many specimens of dead *Deltocyathi* in 270 fathoms off Havanna, one of which he sent to me. A careful examination of the Miocene, West-Indian, and Australian forms leads to the belief that they are not specifically distinct, and that no one would consider them other than varieties if the localities whence they had been derived were unknown. There is a slight difference in shape, but nothing at all specific; and the costæ are more moniliform in one and more spiny in another specimen. As I cannot distinguish a specific difference, I have called the Australian form "variety *australiensis*;" and I would suggest that Pourtales's *Deltocyathus Agassizi* should be known as variety *Agassizi* of the species *italicus*. The *Deltocyathi* are small forms and very readily passed over; but I could not find any amongst the collections of fossil West-Indian corals I have examined. No species have been found in the great Coral ocean.

The *Sphenotrochi* of the Australian Cainozoic deposits differ from all others in having a curious notch at the base. In one species this is so marked as to produce the appearance of two lateral processes on either side of the base. They present, moreover, an anomalous relation between the septa and the costæ. The existing species of the genus are found around the S.W. of England and the Irish coast; and the fossil forms are to be distinguished in European Eocene and Miocene strata and in the Crag. All these have the septa continuous with the costal projections. The Australian species have the septa not continuous with the costæ, but with the intercostal spaces, so that the costæ are on the outside of the interseptal spaces. No living species of the genus have been found in the great Coral ocean, or in the West Indies. The alliance between the genera *Sphenotrochus* and *Placotrochus* is strengthened by the discovery of the Australian forms of the former genus.

Conotrochus is a genus founded upon some well-marked Sicilian corals by Seguenza. They were found in the uppermost of the so-called Miocene strata or the "Marne Giallastre," which are below the horizon of *Flabellum siciliense*, Edw. & H. (lowest beds of Older Pliocene). The generic characteristics are those of a Turbinolian without pali. The corallum is simple, fixed when young, free when old. The columella is fascicular and well-developed. There is a strong epitheca. The shape of the corallum is clavate, turbinate, cylindro-conical, straight or curved.

The only Sicilian species is *Conotrochus typus*, Seg., a most variable form. M. Seguenza sent me a collection of specimens of the species, and there has been no difficulty in determining the specific identity of the Australian and Sicilian forms. The second, Australian species, *Conotrochus M'Coyi*, differs from *Conotrochus typus* in the stoutness of its epitheca, in its form, and in its small calice and columella. The genus is not represented in the recent coral faunas or in any strata except the Sicilian marl and the Australian Cainozoic.

The four species of the genus *Flabellum* found in the Australian tertiary deposits are very remarkable. Two of them are peculiar to the strata, and the others are well-known in the faunas of the Red Sea and the China and Japan seas. The genus is large, and numbers about fifty species, which are divided into those with a very small pedicel, those with a large base which was once attached (*truncata*), those always adherent by a large base, and those having root-like processes of epitheca.

The species hitherto recognized in the fossil condition belong to the first division; but in the Australian Tertiaries two of the truncate forms are found.

The recent species are found especially in the great Coral ocean between the east coast of Africa and the west coast of America. Many are found in the Red Sea, and in the Chinese and Japanese seas; and one exists off the coast of New Zealand. None have been found in the West-Indian seas; but a degenerate form lives in the North Sea, the Bay of Biscay, and probably in the Mediterranean. The truncate division contains many species; and those whose localities are known range from China, the Philippines, and Indian Ocean to the Australian coast near Hardy Island. The division with a small pedicel had a species in the Lower Chalk, many in the Eocene of Europe and America, and a considerable number in the Miocene and Pliocene deposits of Europe. The species found in the Miocene of the West Indies were two in number only.

Flabellum distinctum, which is found in two of the beds near Cape Otway, is a well-known form in the Red Sea and off the coast of Japan. With *Flabellum pavoninum*, Lesson, of Singapore and China, *F. extensum*, Michel., found in the European Miocene and, probably, Oligocene strata, *F. intermedium*, Edw. & H., from the Miocene of Tortona, and *F. Basteroti*, Edw. & H., of the Faluns, the *Flabellum distinctum* forms a series of very indistinctly separable species. They are all probably varieties of an early type, and are not worthy of the title of separate species. Finding the so-called species *F. distinctum* in the Cainozoic of Australia, and in the sea to the north-east, does not interfere with the belief that all the forms just mentioned have lasted, interrupted only by slight variation, from the Oligocene up to the present time.

Flabellum gambierense is a pedicellate form. During its youth it has no spines, and is almost claviform; but with age it grows tall and curved, and throws forth curiously twisted processes of epitheca. It is not like any other *Flabellum*. *Flabellum Candeanum* and *F. Victoriæ* are the fossil truncate species. The first is found in the

China seas; and the last is closely allied to such forms as the recent *F. Stokesi* and *F. crassum*; but it has a fair specific distinction in the development of its septal cycles. Moreover *F. Victoriæ* has the peculiar arrangement of the septo-costal structures mentioned in treating of the *Sphenotrochi*.

Placotrochi are *Flabella* with an essential and lamellar columella; and there are species mimetic of the divisions of the genus *Flabellum*. There are two recent species. One, *P. Candeanus* (China), has a pedicellate base, and is closely allied to *Placotrochus elongatus* from the Australian Tertiaries; and the other, *P. lævis*, is truncate, and is not represented in the fossil state. *Placotrochus deltoideus* is a fine species, and is very characteristic of the Australian Tertiaries.

The genus is not represented in any European formation; but it has four species in the Miocene of Jamaica and San Domingo. It has not been distinguished, as yet, amongst the results of the dredgings off Florida and Havanna. The West-Indian species are very distinct from the Australian, and have only a generic affinity with the Chinese recent forms.

The interesting characters of *Palæoseris Woodsi* have already been noticed. The genus is allied to *Turbinoseris*, Duncan, from the Lower Greensand, but it has no tertiary or recent congeners.

Cycloseris tenuis is closely allied to *Fungia tenuis*, Dana, which is probably a *Cycloseris*. The thin *Cycloserides* are well-known fossils in the nummulitic rocks of the S. of France; and there is one species in the Cenomanian. The recent species are from the Philippines and China.

Amphihelia incrustans is closely allied to *A. venusta* of the Australian coast. The dwarfed and incrusting nature of the coral, and its excessively rare calices and great amount of intercalicular tissue, covered with costæ, distinguish the fossil form from all the others of the genus. The *Amphiheliæ* range from the Miocene of Sicily to the recent deposits in the deep sea of the N.E. Atlantic, where the earliest species still exists. Recent investigations into the affinities of the Oculinidæ, which are not yet finished, lead me to expect that this Australian fossil form is most closely allied to some from the Atlantic.

The most interesting of the corals from the Cainozoic deposits of South Australia are the *Conosmiliæ*. It is a genus perfectly Australian in its abnormalities. A simple coral with a pellicular epitheca, having a beautiful herring-bone ornamentation, with an essential, twisted, "sérialaire" columella with endothecal dissepiments, and with plain septa, which have the hexameral arrangement in some and the octomeral in others, is a form containing the elements of several classificatory series. The irregular septal arrangement amongst the closely allied species may be considered to depend upon atavism. Such octomeral cyclical arrangements occurred in some genera in the Lower-Greensand period and during the Oolites. Some of the Liassic *Montlivaltiæ* clearly reflected this rugose peculiarity; and *M. Ruperti*, Duncan, had a quaternary cyclical arrangement. It is remarkable that the septo-costal peculiarity already mentioned as occurring in the Australian *Flabellum Victoriæ* and in the two species of *Sphenotro-*

chus, should be noticed in all the species of *Conosmilia*. The continuation of the septa and costæ is likewise wanting in some Liassic *Montlivaltiæ*, and in many simple Rugosa. The importance of the *Conosmiliæ* can hardly be estimated at present; but it is evident they are very synthetic forms, occurring late in the coral faunas of the world. The genus *Haplophyllia*, Pourtales, whose solitary species were dredged in 324 fathoms off the Florida reef, has a styliform columella and an octomeral arrangement of the septa. There are no endothecal dissepiments.

Antillia lens is a discoid form, representing the discoid *Montlivaltiæ* in this genus, which differs from that celebrated Mesozoic one by having a distinct columella. The genus is well represented in the West-Indian Miocene; and there are fossil species in the Arabian, Sindhian and Travancore Miocene. I have lately seen a recent *Antillia* from Batavia. Nevertheless *A. lens* is the only discoid form, and is very beautiful and characteristic.

The eight new species of *Balanophyllia*, and that already known as a form from the Miocene of Tortona, give a very Falunian and Crag facies to the Australian corals as a whole, especially as there are no recent species known in the seas around. There are recent species in the Philippines and close to the American continent at Panama; but they are not amongst those found in the Australian tertiaries. Forming a large proportion of the fossil fauna, the *Balanophylliæ* stamp the deposits with a definite character as regards the depth at which they occurred; and this is rendered almost certain by the bathymetrical disposition of the genera *Caryophyllia*, *Flabellum*, *Placotrochus*, *Sphenotrochus*, and *Amphihelia*. The northernmost Faluns contain vast quantities of *Balanophylliæ* (not of species), a *Flabellum* and *Sphenotrochi*; and there, as in the Australian Tertiaries, every gradation of sea-depth, from the abyss to low spring-tide mark, is represented by species.

The Australian *Balanophylliæ* are as peculiar as most of the other corals, and are very characteristic. I cannot distinguish between one form and *B. italica*, a well-known Italian Miocene species.

VI. Localities.

The strata numbered No. 1 by Mr. Selwyn, and which are 1½ mile west of Cape Otway, contain:—

Flabellum distinctum, *Edw. & H.*
Conotrochus M'Coyi, *Duncan.*
Deltocyathus italicus, *Edw. & H.*, var.
Balanophyllia cylindrica, *Michel.* sp., var.
—— Ulrichi, *Duncan.*

Bed No. 3, of the Upper "Coralline deposits," Cape Otway, contains:—

Amphihelia incrustans, *Duncan.*
Balanophyllia Selwyni, *Duncan.*

No. 4, Clay bed near Cape Otway, with *Trigonia semiundulata*, contains:—

Flabellum gambierense, *Duncan.*
—— distinctum, *Edw. & H.*
Placotrochus elongatus, *Duncan.*
Balanophyllia campanulata, *Duncan.*

No. 7 bed, $2\frac{1}{4}$ miles east of the river Gellibrand, contains :—

Trochocyathus meridionalis, *Duncan*.
—— Victoriæ, *Duncan*.
Cycloseris tenuis, *Duncan*.

No. 9 bed, 3 miles west of the river Gellibrand, contains :—

Conotrochus typus, *Seguenza*.
Flabellum Candeanum, *Edw. & H.*
Placotrochus deltoideus, *Duncan*.
Conosmilia lituolus, *Duncan*.

The Mount Gambier tertiaries contain

Flabellum gambierense, *Duncan*.

The Hamilton tertiaries, Muddy and Violet Creeks, the Murray tertiary deposit, and that of the banks of the Geelong, equivalent formations, contain :—

Caryophyllia viola, *Wood & Duncan*.
Sphenotrochus australis, *Duncan*.
—— excisus, *Duncan*.
Flabellum Victoriæ, *Duncan*.
—— Candeanum, *Edw. & H.*
Placotrochus elongatus, *Duncan*.
—— deltoideus, *Duncan*.
Palæoseris Woodsi, *Duncan*.
Conosmilia elegans, *Duncan*.
Conosmilia anomala, *Duncan*.
—— striata, *Duncan*.
Antillia lens, *Duncan*.
Balanophyllia seminuda, *Duncan*.
—— armata, *Duncan*.
—— tubuliformis, *Duncan*.
—— fragilis, *Duncan*.
—— australiensis, *Duncan*.

No. 3 of the Cape Otway series = "Mount Gambier coralline limestones;" and both are deep-sea sediments.

No. 1 of the Cape Otway series is probably the oldest of the beds; and Nos. 4, 7, and 9 are the equivalents of the Hamilton coral-beds, described by the Rev. Mr. Woods. They are deposits which were formed in shallower water than the "coralline limestones," during a period of subsidence; they were covered as the subsidence persisted by the deep-sea coralline limestones or their equivalents.

VII. The existing Coral-fauna of the Australian and neighbouring seas.

The existing coral-fauna of the Australian seas is tolerably rich in species, even if the forms from the great reefs to the north and north-east be omitted. The New-Zealand seas, and those around Tasmania and the south coast of Australia, contain many genera and species; and a comparison of them with the fossil forms is necessary. The following is a list of the species; but it does not contain the true reef-building forms of the tropical seas to the north, north-west, and north-east of Australia, as they are not within the scope of this essay, no reef-building species having been found in the tertiaries :—

Trochocyathus hexagonalis, *Mantell*. } New Zealand: recent and raised
—— Mantelli, *Edw. & H.* } beaches.
Conocyathus sulcatus, *D'Orb.* Port Jackson: Oligocene, Mayence.
Flabellum affine, *Edw. & H.* Australian coast.
—— rubrum, *Quoy & Gaimard*, sp. New Zealand: 25 fathoms.
Amphihelia venusta, *Edw. & H.* Australia.
Stylaster gracilis, *Edw. & H.* Australia.
—— sanguineus, *Edw. & H.* Australia.
—— granulosus, *Edw. & H.* Australia.

Euphyllia glabrescens, *Chamisso*, sp. Australia.
Isophyllia australis, *Edw. & H.* Port Lincoln.
Favia Bowerbanki, *Valenciennes*, sp. Australia.
Cyphastræa microphthalma, *Lamk.* sp., Australia.
Plesiastræa Urvillei, *Edw. & H.* King George's Sound: in shallow water.
—— Peroni, *Edw. & H.* Australia.
Prionastræa australiensis, *Edw. & H.* Australia.
Cylicia rubeola, *Quoy & Gaimard*, sp. New Zealand.
—— tenella, *Dana.* Australia.
—— Verreauxi, *Edw. & H.* Australia.
—— Smithi, *Edw. & H.* New Zealand.
Echinopora rosularia, *Lamk.* sp. Van Diemen's Land.
Merulina ramosa, *Ehrenberg.* Australia.
Polyphyllia pelvis, *Quoy & Gaimard.* New Zealand.
Mæandroseris Australiæ, *Rousseau.* sp. Australia.
Dendrophyllia axifuga, *Edw. & H.* Port Essington.
Cænopsammia coccinea, *Lesson*, sp. New Zealand.
—— Gaimardi, *Edw. & H.* New Zealand.
—— Urvillei, *Edw. & H.* New Zealand.
—— aurea, *Quoy & Gaimard.* King George's Sound and Port Jackson.
Porites Gaimardi, *Edw. & H.* Australia.
Rhodaræa calicularis, *Lamk.* Australia.

VIII. Table of Species and their distribution.

	Muddy and Violet Creeks. H. T.	Murray tertiaries.	Geelong.	Gambier.	No. 1.	No. 3.	No. 4.	No. 7.	No. 9.	Other strata.	Recent.
Caryophyllia viola	*	...	...	...	...	...	...	...	...	...	...
Trachocyathus meridionalis	...	...	...	...	...	...	...	*	...	...	...
—— Victoriæ	...	...	...	...	...	...	...	*	...	...	...
Deltocyathus italicus (var.)	...	...	...	...	*	...	...	...	...	Miocene Europe.	var. in Caribbean.
Sphenotrochus australis	*	...	...	...	...	...	...	...	...	...	...
—— excisus	*	...	...	...	...	...	...	...	...	...	...
Conotrochus M'Coyi	...	...	...	...	*	...	...	...	...	...	...
—— typus	...	...	...	...	...	...	...	...	*	Old pliocene, Sicily.	...
Flabellum Victoriæ	*	...	...	...	...	...	...	...	...	...	...
—— gambierense	...	...	...	*	...	...	*	...	...	...	...
—— Candeanum	...	*	...	...	...	...	...	...	*	...	China seas.
—— distinctum	...	...	...	...	*	...	*	...	...	...	Red Sea & Japan.
Placotrochus elongatus	*	...	...	...	...	...	*	...	...	...	...
—— deltoideus	*	...	...	...	...	...	...	...	*	...	...
Amphihelia incrustans	...	...	...	...	...	*	...	...	...	...	...
Palæoseris Woodsi	*	...	...	...	...	...	...	...	...	...	...
Cycloseris tenuis	...	...	...	...	...	...	...	*	...	...	... ?
Conosmilia elegans	...	...	*	...	...	...	...	...	...	...	...
—— lituolus	...	...	...	...	...	...	...	...	*	...	...
—— anomala	*	...	...	...	...	...	...	...	...	...	...
—— striata	...	...	*	...	...	...	...	...	...	...	...
Antillia lens	*	...	...	...	...	...	...	...	...	...	...
Balanophyllia campanulata	...	...	...	...	...	...	*	...	...	...	...
—— seminuda	*	...	...	...	...	...	...	...	...	...	...
—— armata	*	...	...	...	...	...	...	...	...	...	...
—— tubuliformis	*	...	...	...	...	...	...	...	...	...	...
—— fragilis	*	...	...	...	...	...	...	...	...	...	...
—— australiensis	*	...	...	...	...	...		...	...	...	...
—— Selwyni	...	...	...	...	...	*	...	...	...	...	...
—— cylindrica (var.)	...	...	...	...	*	...	...	...	...	Miocene Tortona.	...
—— Ulrichi	...	...	...	...	*	...	...	...	...	...	...

IX. Conclusion.

When the list of the fossil corals of the Australian tertiaries is compared with that of the forms living in the Australian and New-Zealand seas, it becomes evident that none of the recent species are represented in the Cainozoic strata. Of the twenty genera now existing around Australia, out of the immediate vicinity of coral-reefs, only three had species in the Tertiaries. *Trochocyathus*, *Flabellum*, and *Amphihelia*, very world-wide genera, were represented in the tertiary strata by species which were very distinct from those now inhabiting the South-Australian and New-Zealand seas. The species which have been found as fossils, and which still exist in the Chinese, Japanese, and Red Seas, are *Flabellum Candeanum*, and *F. distinctum*. The Chinese *Placotrochus Candeanus* is very closely allied to *P. elongatus* from the Hamilton tertiaries and Cape Otway, and the *Deltocyathus* is equally so to a West-Indian recent species. The alliance of the coral faunas of the Australian Tertiaries and of the surrounding coral seas is thus very slight; and the recent species have not been found in the uppermost of the Tertiaries. There are three species common to the Australian and the European Cainozoic deposits; so that the alliance of the Australian fossil fauna is as great with the European Cainozoic fauna as it is with that of the corals of the tropical seas to the north-east. There is a well-marked species of the Lower Miocene or Oligocene of Mayence, still living in Port Jackson, but it has not been found in the tertiary deposits close by.

The fossil fauna now under consideration cannot be satisfactorily compared with any others with the view of determining a geological relationship. The bulk of the species are peculiar, and such genera as *Conosmilia* and *Palæoseris* are very characteristic. Their species, as well as the Australian *Caryophylliæ*, *Trochocyathi*, and *Sphenotrochi*, present those anomalies which appear to distinguish the forms of the New-Holland fauna. The presence of the Italian species *Conotrochus typus*, and of the Tortonese *Balanophyllia cylindrica* and *Deltocyathus italicus*, in the Australian Tertiaries is quite in keeping with the well-known dispersion of the Maltese and Bund corals and Echinodermata.

The corals of the Australian Tertiaries are very characteristic. They were not reef-builders, but forms which tenanted the sea-bottom, from low spring-tide mark to the depth where Polyzoa abound. The species of the different beds have so great a general and exact resemblance, that they do not offer evidence of any great biological changes having occurred during the deposition of the whole of the fossiliferous tertiary sediments. It is therefore not consonant with the rules of classificatory geology to subdivide the sediments into such series as Oligocene, Lower, Middle, and Upper Miocene, and Pliocene, which for the most part have very distinct faunas in the European area. The diagnosis of the age of the tertiary deposits by the percentage system cannot as yet be applied to the Australian sedimentary beds, in consequence of the Mollusca not having been sufficiently studied; and the comparison between the existing Austra-

lian coral fauna and that of the Tertiaries would give a much older geological age to them than is warranted by the physical geology of the area. During the deposition of the Tertiaries there was much disturbance in the currents and constant alterations in the depth of the coralliferous sea, whose bottom and shores were formed by the Silurians, old basalts, and carbonaceous sandstones of Victoria. The conglomerates and pebbly sandstones were of course formed during different marine conditions from those which existed during the deposition of the clays and clayey sands. As the depth increased during the subsidences which evidently followed every basaltic outpouring, the calcareous element mingled with the wash down from the land, and finally it increased to such an extent that it encroached upon the area formerly occupied by littoral deposits, and even in some places covered the rocks whose denudation had produced the conglomerates.

There were temporary upheavals during this general subsidence; and the leaf-beds, with their associated clays, bear testimony to them. The relations of leaf-beds, clays, gypsum, and basic sulphate of iron, so frequently observed in Europe, are repeated in the Australian deposits. The metamorphosis of some of the original contents of these vegetable-bearing clays into gypsum, and the gradual solution of the latter by the natural-drainage waters, may account for the irregular bedding of the Cape-Otway fossiliferous Tertiaries, contortion following the depression incident upon the gradual removal of the salt of lime. The tertiary deposits were not subjected to any other alterations in their relative level than those of the most local kind. There were none of the phenomena of uptilting and crumpling which occurred in the tertiary deposits of the West Indies, Southern Europe, and Sindh; and one fauna did not collect around the ruins of those which had been antecedent to it.

It is reasonable to admit, especially when the long duration of the time which was occupied by the formation of the series over the fossiliferous deposits is considered, that whilst the vast central area of Australia was a sea, there was open water to the north, with reefs in the Java district and corresponding formations opening into what is now the Mediterranean and the Sahara to the north-west. The Indian peninsula, and the area now occupied by the Himalayas and stretching far away to the east, were not part of a great continent; and their marine tracts equalled the terrestrial in magnitude. The greater part of the American continent was submerged, and the Caribbean sea was a coral area. Where was the bulk of the land when the coral-sea stretched round the tropics? It could only have been to the extreme north and south. New Zealand and South Australia were therefore bounded to the north by a coral-sea, and to the south by the deep ocean, as now. So far as the coral-fauna is considered, this separation of the Australian sea from the European area by a coral tract inhabited by a distinct fauna, which could only exist under conditions very diverse from those witnessed in Victoria, is explanatory of the comparative isolation of the remote assemblages of species, supposing them to have existed during the same geolo-

gical period. The enormous range of deep-sea corals is now admitted; and it is certainly very remarkable that so few of them should have become common to the European and Australian tertiary deposits. The absence of any littoral connexion between Australia and the tracts to the north of it during the whole of the tertiary period, and the remoteness of the south of its area from any great centres of frequent terrestrial oscillations, may explain the persistence of type which is so characteristic of a large portion of its fauna and flora*. This persistence was infinitely less in Europe, on account of the more frequent changes in the physical geology of its area, such changes inducing emigration of some forms, unusual competition with others, and occasional free scope for rapid multiplication. Hence the distant and comparatively quiet area of Australia was tenanted by the same species, whilst vast biological and geological alterations took place in the area which was formerly considered the type by which all others could be compared.

The permanent upheaval of the central and northern area of Australia, the extinction of its volcanoes, and the change in its coral fauna were grand phenomena. Considering that a relatively identical age is given to the great upheavals of the Alps and Himalayas, there is some reason for asserting that the Australian and New-Zealandic upheaval was more or less synchronous with them, with the closure of the Isthmus of Panama, and with the depression of the areas on either side of the American continent.

The denudation which occurred during the upheaval of the Australian area was enormous, and it is to be estimated by the extent of the unfossiliferous deposits which cover the fossiliferous marine Tertiaries. There are no proofs of any glacial phenomena in Australia; and subaerial denudation probably went on during the whole of that vast period, and has continued. The whole of the paying gold-drifts were formed after the deposition of the marine fossiliferous strata; and thus the sandy ferruginous clays, coarse pebble-grits, and hard ironstone cements and conglomerates, together with the lava-plains to the north of Cape Otway, are younger than the Mount-Gambier polyzoan limestones. Above these latter deposits are great beds of blown sand, dunes, lacustrine formations, raised beaches, and estuarine deposits. There are some lignites, shelly and siliceous sands, and volcanic ashes between these two series, which attain the height of 130 feet at the mouth of the river Gellibrand.

These remarks will have prepared us for a condemnation of the terminology usually employed by Australian geologists. I would suggest that the word Tertiary should be only used relatively in Australian geology, and that the strata (so ably mapped by the surveyors) which are above the carbonaceous sandstones should be called Cainozoic. The term Lower Cainozoic would refer to all the deposits beneath the Mount-Gambier series, the Middle to that deposit, and the Upper to all above.

It would be as well not to establish a too local terminology; for

* The islands of Papua and to the south of the Straits of Bali were probably connected with Australia at this time.

sooner or later the cainozoic deposits of New Zealand, which attain probably a greater magnitude in depth than those of Australia, will be found to render the establishment of a great southern series necessary.

The Tertiaries of the North Island of New Zealand must be studied in relation to those of Australia. The great development of tertiary limestone between the Rangetoto range and the west coast of the North Island of New Zealand requires careful examination, especially as regards its fossils. Its relation to the lignites of what Hochstetter has called the Auckland Tertiaries, has been satisfactorily determined; and by a comparison of the fossils with those from the Cape-Otway series a sufficiently satisfactory equivalency might be established; so that a local terminology could be agreed upon, without binding geologists to the inevitable results of the adoption of the European classification of the succession of deposits during the tertiary period.

The polyzoan limestones of the North Island of New Zealand were probably the equivalents of the Mount-Gambier deep-water deposits. As yet no reef-building forms have been discovered in them.

The equivalency of all the cainozoic deposits described and noticed in this communication is probably as follows. The lowest bed, No. 1, $\frac{1}{2}$ mile west of Cape Otway=the gravel- and boulder-deposit, and the old basalt of the inland valleys. Next in succession is No. 9, 3 miles west of the river Gellibrand, and then No. 4, clay-bed near Cape Otway, with *Trigonia semiundulata*. Nos. 9 and 4=the Hamilton tertiaries, the Geelong and Murray beds, below the so-called coralline limestone (with hardly a coral in it, but plenty of Polyzoa). Polyzoan limestone of Mount Gambier=No. 3, near Cape Otway. It often becomes more sandy as it overlaps the inferior but really contemporaneous deposits.

There are no neighbouring areas with whose strata these can be correlated. The tertiary formation of Java has been magnificently illustrated, so far as its corals and Echinodermata are concerned, by Reuss and Herklots; but it was deposited under the conditions peculiar to a reef-area. The fossil corals were reef-building, and had the old-fashioned facies which is characteristic of the Australian fauna.

The palæontology of the coral limestones of the coasts of the great islands to the east of New Holland is a blank; and even the great raised reefs of the Sandwich Islands have not been studied. The Caribbean tertiaries have hardly any thing in common with the Australian, and were deposited in a reef-area. With these considerations and facts before us, the necessity for a critical examination of the New-Zealand Tertiaries becomes most urgent.

At present all that can be arrived at concerning the relative position of the Australian fossiliferous Tertiaries and their physical geology may be quickly summed up. They were formed on a sea-bottom of the oldest rocks, in increasingly deep water, during a period when the denudation of the neighbouring coast-line to the east and north-east was rapid. They were very distant from the reef-area of the

period; and the physical conditions of such an area were never present during the deposition of the Madreporaria, Polyzoa, Echinodermata, and Mollusca, which have a facies characteristic of all the European marine tertiary deposits above the Nummulitic. They were subjected to frequent volcanic outbursts, which covered large areas with basalt and ash, and they were covered, after the general upheaval of the centre of Australia, with lacustrine, dune-, river-, and torrent-deposits, whose depth testifies to the enormous denudation of the older rocks. The condition of the high land on the extreme east and west of Australia was probably that of dry land during the whole Cainozoic period; and these districts bounded the tertiary sea.

EXPLANATION OF PLATES XIX–XXI.

Plate XIX.

Fig. 1 *a*, *Caryophyllia viola*, Duncan and Woods, × 2; 1 *b*, calice, magnified; 1 *c*, costæ.
2 *a*, *Trochocyathus meridionalis*, sp. n., × 2; 2 *b*, calice, magnified; 2 *c*, costæ.
3 *a*, *Trochocyathus Victoriæ*, sp. n., × 2; 3 *b*, calice, magnified; 3 *c*, costæ.
4 *a*, *Deltocyathus italicus*, Edw. & H., var. *australiensis*, calice, magnified; 4 *b*, base, magnified; 4 *c*, costæ, magnified.
5 *a*, *Sphenotrochus australis*, Duncan, × 2; 5 *b*, calice, magnified.
6 *a*, *Sphenotrochus excisus*, Duncan, × 2; 6 *b*, calice, magnified; 6 *c*, portions of calicular margin, magnified, to show relative position of costæ and septa.
7 *a*, *Conotrochus M'Coyi*, sp. n., × 2; 7 *b*, calice, magnified.
8 *a*, *Conotrochus typus*, Segu., var. *australiensis*, × 2; 8 *b*, calice, magnified; 8 *c*, epitheca, magnified.
9, *Flabellum gambirense*, Duncan, × 2.
10 *a*, The same, × 2; 10 *b*, calice, magnified; 10 *c*, epitheca, magnified.
11, *Flabellum Victoriæ*, Duncan, × 2.

Plate XX.

Fig. 1 *a*, *Flabellum Candeanum*, Edw. & H., nat. size; 1 *b*, calice, magnified; 1 *c*, base of corallum, magnified; 1 *d*, side view of a septum, magnified.
2, *Flabellum distinctum*, Edw. & H.
3 *a*, *Placotrochus elongatus*, Duncan, slightly enlarged; 3 *b*, calice, magnified; 3 *c*, peduncular extremity, magnified.
4 *a*, *Placotrochus deltoideus*, Duncan, nat. size; 4 *b*, columella and septa, magnified.
5, *Conosmilia elegans*, Duncan, enlarged.
6, *Amphihelia incrustans*, sp. n., enlarged.
7 *a*, *Palæoseris Woodsi*, Duncan, enlarged; 7 *b*, septa, magnified, showing synapticulæ.
8, *Cycloseris tenuis*, sp. nov.
9 *a*, *Conosmilia striata*, Duncan, enlarged; 9 *b*, calice, magnified; 9 *c*, epitheca, magnified.
10 *a*, *Conosmilia anomala*, Duncan, nat. size; 10 *b*, calice, magnified; 10 *c*, upper part, magnified, showing columella and endotheca.
11 *a*, *Conosmilia lituolus*, sp. n., enlarged; 11 *b*, calice, magnified.
12 *a*, *Antillia lens*, Duncan, septa, magnified; 12 *b*, side view of septum.

Plate XXI.

Fig. 1 *a*, *Balanophyllia campanulata*, sp. n.; 1 *b*, part of calice, magnified; 1 *c*, costæ, magnified.

Fig. 2 *a*, *Balanophyllia seminuda*, sp. n., enlarged 2 diams.; 2 *b*, part of calice, magnified.
3 *a*, *Balanophyllia armata*, sp. n., enlarged 2 diams.; 3 *b*, part of calice, magnified; 3 *c*, costæ, magnified
4 *a*, *Balanophyllia Selwyni*, sp. n., slightly enlarged; 4 *b*, part of calice, magnified.
5 *a*, *Balanophyllia fragilis*, sp. n., part of calice, magnified; 5 *b*, costæ, magnified.
6 *a*, *Balanophyllia australiensis*, Duncan, enlarged 2 diams.; 6 *b*, part of calice, magnified; 6 *c*, costæ, magnified.
7 *a*, *Balanophyllia cylindrica*, Michel., var. *α*, nat. size; 7 *b*, part of a calice, magnified.
8, *Balanophyllia Ulrichi*, sp. n., nat. size; 8 *a*, the same var., enlarged 2 diams.; 8 *b*, part of calice, magnified; 8 *c*, costæ, magnified.
9, *Balanophyllia tubuliformis*, sp. n., part of calice, magnified.

Discussion.

The President inquired whether the absence of reef-corals might not be indicative of the climate of South Australia having been much the same as at present in Tertiary times, as these forms required a temperature of about 68°.

Prof. Ramsay expressed his satisfaction at the manner in which Mr. Selwyn's work on the Australian Geological Survey had been appreciated by the author.

Mr. Jenkins, who had been working on the fossil mollusca of Australia, had arrived at the conclusion that at the time of the deposit of the beds mentioned by Dr. Duncan, the climate had been warmer than at present. The shells presented the same strange and abnormal features as the corals, in differing from other older and well-known species merely in some minute detail. There was no point of contact between the Australian and European faunas to afford a criterion of relative age, though there were some points of similarity to be found in the Mediterranean area.

Mr. Gwyn Jeffreys stated, as an instance of the singularities of the Australian fauna, that *Rhynchonella psittacea*, essentially an arctic species, had occurred in the Tertiaries of Spain, in our Glacial deposits and the Norwich Crag, and is now found living in Australia.

Dr. Duncan shortly replied to the various speakers, and was disinclined to limit the occurrence of any forms of corals to particular temperatures.

---

2. Note *on a* New *and* Undescribed Wealden Vertebra. By J. W. Hulke, Esq., F.R.S., F.G.S.

[Plate XXII.]

This vertebra was found on the shore near Brooke, Isle of Wight, almost completely hidden in a large block of stone. Last autumn, when I obtained it, I showed the block to Mr. Fox, of Brighstone, whose knowledge of the Wealden strata in this neighbourhood is unrivalled; and he without hesitation referred it to a bed which occurs near the top of the high cliff between Brooke and Chilton.

The centrum has unfortunately been broken across, and the greater part of it, including both articular faces, is missing. Only a small part of it, including the floor of the neural canal, remains, surmounted by a singularly framed superstructure, which, although much distorted by pressure, is yet sufficiently preserved to afford a good idea of its perfect form.

The bony tissue is very compact, which makes the outer surface very smooth, and even polished. It takes principally the shape of thin plates, many of which are not thicker than stout writing-paper. Where the interior of the stouter parts of the vertebra is exposed, the broken surfaces show a thin outer shell of bone enclosing an extremely coarse cancellated tissue, the spaces of which are immense, exceeding by many times those of the cancellous tissue of all the contemporary Dinosaurs yet known to us, and reminding us in some measure of those of Pterodactylian bones.

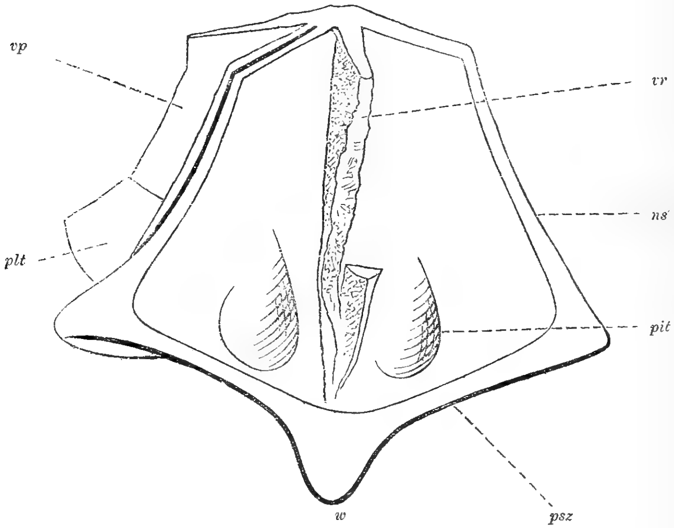
The neurapophyses (Pl. XXII. figs. 1 & 2, *np*), in their present mutilated state, measure about 5 inches from front to back; but their real length was greater, for they have suffered by the compression of the back of the vertebra. How far they descended on the sides of the centrum is not determinable; but their present height measures about 5 inches from the floor of the neural canal to the level of its crown; and from that to the level of the root of the neural spine is nearly 1 inch more. Their anterior margin is stout, their posterior margin thinner; and intermediately their substance is reduced to a very thin lamina, the outer surface of which is strengthened by a series of minor buttresses and arches projecting in high relief. The greater stoutness of their anterior margin has reference to the support of the large præzygapophyses.

These latter articular processes (*prz*) project directly forwards in front of the neural spine, and they overhang the entrance of the neural canal (*nc*). Their anterior inferior angle is borne by a stout buttress which springs from the front of the neurapophysis. They have two articular surfaces:—a larger upper one, of a flat, oblong, tabular form, at the level of the base of the neural spine (the crown of the arch), directed upwards and slightly inwards, for articulation with the corresponding large oblong face of the postzygapophysis; and a smaller subtriangular articular surface directed inwards towards the middle line, forming the sides of a notch separating the two præzygapophyses (figs. 1 & 3, *n*). This notch is nearly 2 inches deep from front to back. Its width is ·7 inch behind, and about 1·3 inch in front.

The postzygapophyses (fig. 4, *psz*) lie directly under the posterior pillars of the neural spine (to be presently described). Their size and shape correspond to those of the præzygapophyses; and their direction is the reverse, viz. downwards and slightly outwards. No notch intervenes between them as between the anterior articular processes; but their inner borders coalesce in the middle line, and from their junction a stout plate (fig. 4, *w*) descends vertically to the crown of the neural canal—in other words, to the summit of the neural arch. This plate measures nearly 2 inches vertically, and it is ·9 inch thick.

On applying a fragment of the back of a vertebra in Mr. Fox's collection (woodcut), we found that when the postzygapophyses rested on the præzygapophyses, the posterior vertical median plate fitted into the notch between the latter, its sides articulating with the subtriangular articular surfaces of these.

Fig. 1.—*Reduced outline of a camera-drawing of a fragment of the back of a similar vertebra in Mr. Fox's collection.*



ns'. Posterior pillars of composite neural spine.
psz. Postzygapophyses.
w. Vertical median wedge-plate descending from junction of *psz* to crown of neural canal.
vr. Vertical mesial ridge, for interspinous ligament.
vp. Thin vertical plate descending to platform.
plt. Horizontal platform.

The neural spine consists of an anterior pair of pillars (now about 7 inches long) which rise from the crown of the neural arch immediately behind the præzygapophyses (*ns*), and of a posterior pair of stouter pillars (*ns'*) which ascend from immediately above the postzygapophyses. The two front and the two posterior pillars are joined by a thin lamina; and other thin plates pass between the front and back pair. The plate which unites the two front pillars is indented; so that these pillars are separated by a deep retiring angle, open forwards; while the plate which connects the two posterior pillars developes a vertical median crest (*vr*) projecting backwards, and having a strong, rough edge, as if for the attachment of an interspinous ligament. Below, the crest contracts, and ends in a deep hollow just above the union of the inner borders of the postzygapophyses.

The transverse processes (*tr*) are simple, stout and short. They project horizontally outwards from the outer border of the præzygapophyses. The left one, which appears to be unmutilated, measures nearly 3·5 inches along its upper surface. It bears a terminal, oval, slightly hollow costal surface (*cs*), the long axis of which, nearly vertical, measures 2·5 inches, while the horizontal shorter axis is 1·1 inch. The under surface of the transverse process rests on a strong buttress-like plate, which ascends towards its outer end from the anterior margin and adjacent outer aspect of the neurapophysis. This plate forms the outer wall of a large and deep triangular hollow beneath the anterior margin of the transverse process.

One of the most remarkable characters in the vertebra is a thin horizontal platform (*plt*) which extends along the side of the vertebra, from the back of the transverse process anteriorly to the postzygapophyses behind, in the level of the crown of the arch. Its original breadth is not now ascertainable, for its outer border is broken; but in its present mutilated state, it extends outwards to the distance of 5 inches from the neural spine. It is strengthened in front by a stout ridge produced outwards from the outer half of the posterior border of the præzygapophysis and the adjacent anterior pillar of the neural spine. A curved notch, 2 inches long, the only remaining natural edge of the platform, separates the outer end of this ridge from that of the transverse process. At about 2·5 inches behind the first ridge the platform is strengthened by a second; and, corresponding to this, a strong bracket-like plate (*btt*) descends from the under surface (of the platform) towards the centrum, filling the angle included by the horizontal under surface of the platform and the nearly vertical outer surface of the neurapophysis. The lower end of this bracket forks just before it reaches the centrum. Between the bracket and the buttress which springs from the anterior border of the neurapophysis to the outer end of the transverse process, is a very large deep hollow under the platform. Its sides are formed by the bracket and buttress just mentioned; and its bottom corresponds to the thinnest part of the neurapophysis, which at this part is only about ·1 inch thick, and is strengthened by small buttresses and arches in high relief. A similar but smaller hollow is present behind the great vertical bracket, between it and the postzygapophysis. A third, and still smaller pit occurs at each side of the vertical median plate descending from the postzygapophyses to the arch, which allows the entrance of the plate into the notch between the præzygapophyses when the vertebræ are articulated. From the upper surface of the platform several thin strut-like plates ascend on the sides of the neural spine.

The neural canal (*nc*) has a singular construction, which I do not remember to have seen in any other vertebra. The anterior margins of the neurapophyses form a wide, simple, low-spanned opening; and within this there is a very beautiful interior arch (*g*) with groins projecting from the spring of the arch and from the roof, and converging to a central point lying just under the front of the neural

spine, distant about 1 inch from the bottom of the notch between the præzygapophyses. The posterior opening of the neural canal is much narrower than the anterior: only the upper part of it remains; its sides form an angle of about 80°.

One of the first questions which arises is, to what region of the spine does this vertebra belong? In the almost complete absence of the centrum, this question cannot be certainly answered. Its cumbrous size, the great platform, and the restraint which the superadded median bolt and notch impose on the play of the zygapophyses point, I think, to the trunk. Next, the small size and the direction of the articular facet at the end of the transverse process appear ill suited to constitute it the sole and sufficient vertebral support of a rib of dimensions commensurate with those of the vertebra. This makes it likely that there was a capitular costal articular surface on the side of the centrum; and a double costal vertebral articulation, taken in connexion with the other character, points to the front half of the trunk.

The marked reptilian character of the Wealden fauna favours the presumption that this is also the vertebra of a reptile.

Shortly summed, its distinctive features are:—

Textural.—The compactness of the osseous tissue, its occurrence chiefly in thin plates, the thinness of the cortical layer of the bone, and the immense spaces of the cancellous tissue.

Constructive.—1. The vertical median plate, or bolt, beneath the postzygapophyses, and the corresponding notch between the præzygapophyses.

2. The composite neural spine.

3. The great platform.

4. The buttresses and arches by which the spine, neurapophyses, transverse processes, and platform are strengthened, and the groined interior arch at the front of the neural canal.

The peculiar textural characters enable us readily to separate these from other Wealden bones. My attention was first drawn to these four years ago by Mr. Fox, who had already at that time collected many fragments of this sort from the Wealden cliffs in the neighbourhood of Brighstone, not one of which, however, was sufficiently complete for me to glean an idea from it as to the part of the skeleton from which it had come. The texture of these fragments reminded me more of the coarse diploë of the Elephant's skull than of any thing else with which I was acquainted. They told of the former existence of a large animal distinct from any of the known Dinosaurs, having a skeleton comparable for its lightness with that of Pterosauria, but of a size far surpasing any of these. About a year after this, while examining the Streptospondylian vertebræ in the British Museum, I was struck with the close resemblance, as regards colour and texture, of one of these to the pieces of bone which Mr. Fox had shown me, and the suspicion arose in my my mind that these were portions of this *Streptospondylus*. I have lately reexamined this vertebra, and find the same textural simila-

rity to mine. Unfortunately the comparison cannot be extended to their form, since my arch &c. wants nearly the entire centrum, and the British Museum centrum bears only a very worn and mutilated upper structure. Their identity must therefore be left at present undetermined*.

Two of the leading features in the frame of this new vertebra, the median wedge and notch (accessory to the ordinary articulating surfaces of the zygapophyses), and the broad platform, point in the direction of Dinosauria. The wedge and notch (similar in principle, but differently placed to the zygosphene and zygantrum of Snakes), which, till very lately, I believed to be peculiar to this vertebra, are present also, Prof. Huxley tells me, in *Megalosaurus*; and the platform upon the neural arch is one of the marks of *Iguanodon Mantelli*.

Dimensions.

	inches.
Neurapophyses, length (from front to back) about	5
,, height to top of neural canal, about	5
,, ,, crown of arch	6
Præzygapophyses. Upper articulating surface.	
Transverse diameter (or from median to outer border)	3·2
Antero-posterior diameter	1·9
Interpræzygapophysial notch.	
(Antero-posterior) length	2
Width, behind	·7
,, in front	1·3
Vertical wedge beneath the postzygapophyses.	
Vertical depth	2
Thickness	·9
Transverse process.	
Length along upper surface	3·5
Costal articulating surface, vertical diameter	2·5
Horizontal diameter	1·1
Platform (broader than)	5
Neural spine (pillars), length	7

* Should it hereafter be established, there will still be the question, What is this *Streptospondylus*? The vertebra is in the North Gallery. It bears the Catalogue number 28632, and also a written label with the words "Wealden, S.E. England;" and it formed part of the Mantellian collection. It differs from all the other opisthocœlian vertebræ in the National Collection, not merely in its texture, but also in its form and proportions, and more particularly in the presence of a very large and deep excavation in the side of the centrum, nearly perforating it, beneath the neural canal. In position, this pit corresponds, as Mr. Seeley has lately pointed out, to the pneumatic foramen of the Pterodactylian vertebra. But should any one be tempted to conjecture, from the presence of this pit, together with the very open texture of the bone, that this *Streptospondylus* was an enormous flying Saurian, he will do well to bear in mind that an extremely light skeleton does not necessarily prove endowment with flight, and also that all Pterosaurian vertebræ yet known are procœlian, and what perhaps is of minor importance, that the horizontal diameter of their articular

DESCRIPTION OF PLATE XXII.

In all the figures the same parts are indicated by the same letters.

Fig. 1. Front view. Fig. 2. Oblique view of front and left side. Fig. 3. View of under surface. Fig. 4. Back view. Reduced.

ns. Anterior pillars of neural spine, thrown backwards, downwards, and towards the left by pressure.
ns'. Posterior pillars of neural spine.
vr. Vertical ridge, rough for attachment of an interspinous ligament.
prz. Præzygapophyses.
n. Interpræzygapophysial notch, = zygantrum.
z. The inner articular surface of the right præzygapophysis, forming one side of the notch.
w. The vertical wedge-plate descending from the junction of the postzygapophyses to the crown of the neural canal, which, when the vertebræ are articulated, is received into *n*, the notch between *prz*. It has been dislocated towards the left.
psz. Postzygapophyses.
np. Neurapophyses.
g. Groined interior arch.
nc. Neural canal.
fl. Its floor.
c. A small portion of the upper part of the centrum immediately under *fl.*
tr. Transverse process.
cs. Costal facet.
plt. Horizontal platform.
btt. Vertical buttress-plate descending from platform to centrum.

Discussion.

The President remarked on the combination of strength and lightness in the bone, which in this respect was not unlike the vertebræ of the back of the ostrich.

---

3. *Note on the* Middle Lias *in the* North-east *of* Ireland. By Ralph Tate, Esq., Assoc. Linn. Soc., F.G.S.

Portlock in his 'Survey of Londonderry' makes no mention of the presence of the Middle Lias in Ireland; and an examination of the species of fossils collected by him proves that no higher member of the Jurassic series than the Lower Lias is represented by them. In a former communication* I demonstrated the presence of the whole series of the Lower Lias, and, till recently, was unaware of the occurrence of strata newer than that formation.

Mr. William Gray has sent me several blocks of a grey, marly, micaceous sandstone, charged with organic remains of Middle Liassic age; these were obtained near the town of Ballintoy, "in fields

faces exceeds the vertical (Owen); while in this *Streptospondylus* the reverse obtains, the vertical diameter of the best-preserved articular face (the hollow, posterior one) exceeds the transverse.

* Quart. Journ. Geol. Soc. vol. xxiii. p. 297 (1867).

Fig. 1.

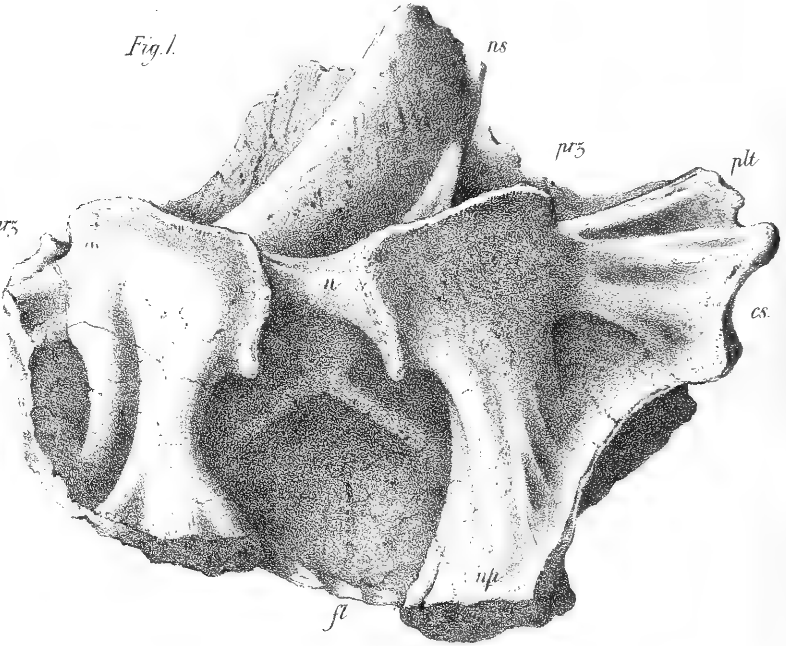


Fig. 3.

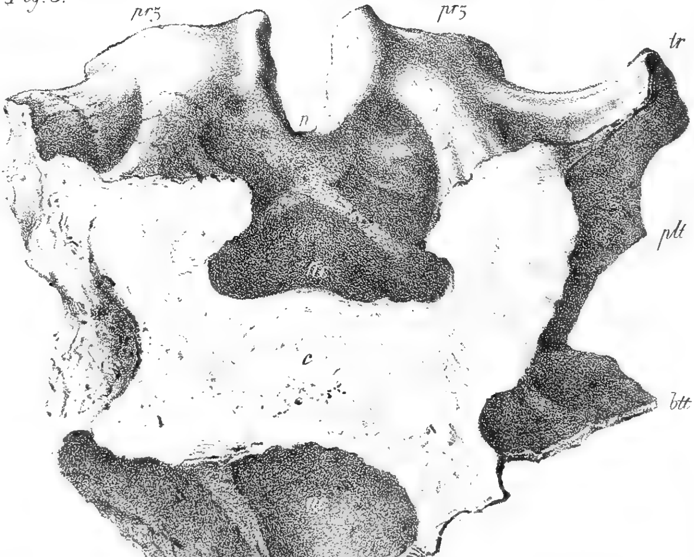


Fig 2

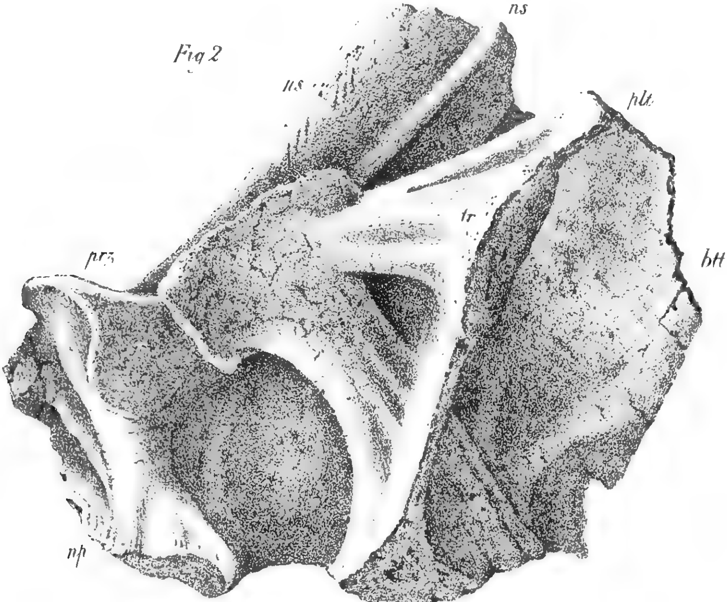
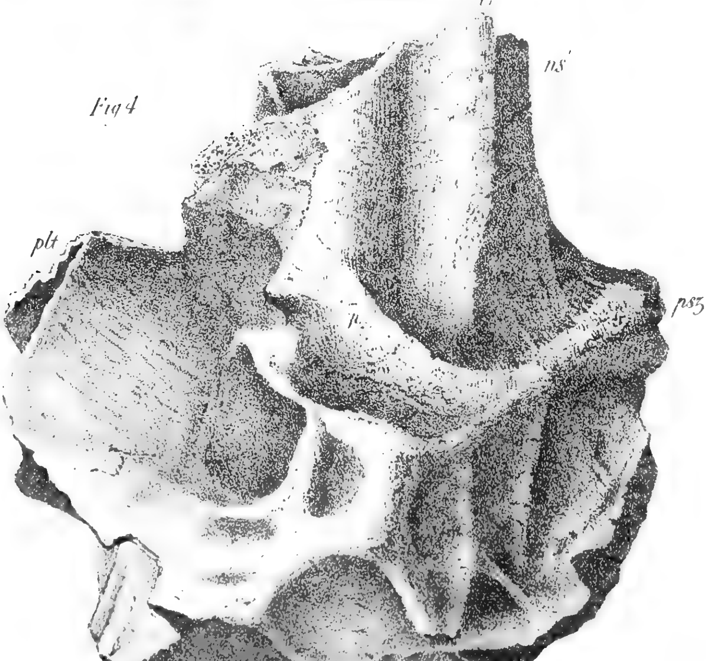


Fig 4



M & N Hanhart imp.

ERTEBRA

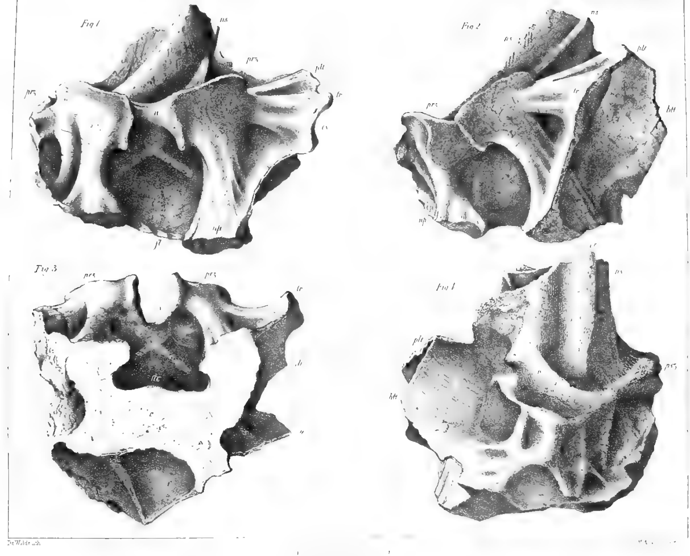


Fig 1
ns
prz
plt
tr
np
Fig 2
ns
plt
prz
tr
btt
np
Fig 3
prz
tr
Fig 4
plt
prz
btt

and cultivated patches of drift," and conjectured by the discoverer to have been derived from the immediate vicinity; but up to the present time they have not been referred to their parent site.

I have determined the following species:—

1. Ammonites margaritatus, *Montf.*
2. Ammonites Henleyi, *Sow.* (on the authority of Mr. R. Etheridge).
3. Belemnites umbilicatus, *Bl.*
4. Pitonillus turbinatus, *Moore.*
5. Pecten liasinus, *Nyst.*
6. Pecten acutiradiatus, *Schloth.*
7. Plicatula spinosa, *Sow.*
8. Cypricardia cucullata, *Goldf.*
9. Isocardia cingulata, *Goldf.*
10. Limea acuticosta, *Goldf.*
11. Avicula novemcostæ, *Brown.*
12. Rhynchonella acuta, *Sow.*
13. Rhynchonella variabilis, *Schloth.*
14. Waldheimia numismalis.
15. Pentacrinus, sp.
16. Hybodus reticulatus, *Ag.*?

With the exception of *Plicatula spinosa*, *Avicula novemcostæ*, and *Rhynchonella variabilis*, which range throughout the Lower and Middle Lias, the majority of the determined species indicate an horizon below the Marlstone but above the highest beds of the Lower Lias. The close similarity in lithological composition, and in part in fossiliferous contents, between the Pabba shales* and the blocks found at Ballintoy suggests the probability of the latter having been transferred during glacial times from the Hebrides.

Nevertheless the sandstone blocks from Ballintoy belong unquestionably to the Middle Lias, and appertain to the lower division, which includes the *Jamesoni*-bed, the *Ibex*-bed, and the *Capricornus*-bed, and are contemporaneous (if not conterminous) with the Pabba Shales.

February 23, 1870.

Alexander G. H. Harding, Esq., of King's College, and 39 Woburn Place, Russell Square, W.C.; Thomas Adair Massey, Esq., Barrister-at-Law, 6 Crown Office Row, Temple; and Samuel Haslett, Esq., Ann Street, Belfast, were elected Fellows of the Society.

The following communications were read:—

* Geikie, Quart. Journ. Geol. Soc. vol. xiv. p. 5 (1858).

1. Additional Observations *on the* Neocomian Strata *of* Yorkshire *and* Lincolnshire, *with* Notes *on their* Relations *to the* Beds *of the same age throughout* Northern Europe.

By John W. Judd, Esq., F.G.S., of the Geological Survey of England and Wales.

[Plate XXIII.]

Contents.

I. Introduction.

In two previous communications* I have laid before this Society the result of detailed studies of the fine cliff-section of Filey Bay in Yorkshire, and of the range of hills forming the western flank of the Lincolnshire Wolds. In each of these memoirs I have especially dwelt on the presence and relations of certain beds, which are proved by their fossil contents to belong to the great formation known by the names of *Néocomien* in France and Switzerland, of *Hils* in North Germany, and of *Biancone* in Italy. In pursuing this subject on the present occasion I propose,—first, to describe the inland development of these beds in Yorkshire; secondly, to furnish some additional particulars concerning the Lincolnshire beds; thirdly, to give a brief *résumé* of the whole of the facts known regarding the nature and relations of the Neocomian strata of the north of England; and, lastly, to state the results of a personal examination and comparison of these beds with their equivalents in North-western Germany.

II. Neocomian Strata of the Vale of Pickering.

On the completion of my study of the succession of strata exposed in the cliffs of Filey Bay, it became an object of much interest to me to examine and map, as far as possible, the *inland* development of the same beds (Neocomian, Portlandian, and Kimmeridge), with a view to the confirmation or correction of the conclusions I had then arrived at concerning their nature and relations. Unfortunately the whole district between the Wolds and moors of Yorkshire is so thickly covered with drift and alluvium as to render the examination of the underlying deposits a task of great difficulty.

The Vale of Pickering was first excavated during preglacial times, in the soft Neocomian and Upper Oolitic clays which intervene between the harder rocks of the Upper Cretaceous and the Lower

* Quart. Journ. Geol. Soc. vol. xxiii. p. 227 (1867), vol. xxiv. p. 218 (1868).

Oolitic series, by streams which probably flowed from W. to E. During the Glacial period this valley was filled with immense deposits of the Boulder-clay and its associated beds; and on the re-emergence of the land from beneath the Glacial sea, the present rivers (the Derwent and its affluents), flowing from E. to W. and cutting a narrow gorge through the harder strata of the Howardian hills, scooped out the valley again, but not to so great a depth as before*. Thus the clay-beds, which formed the bottom of the original valley, remain (especially in their eastern part) to a great extent concealed by drift-deposits, as represented in the ideal section (Pl. XXIII. fig. 1).

Having pointed out the obstacles to complete examination of the inland development of the Neocomian beds of the district, I now proceed to describe in detail all the facts which I have been able to collect concerning them.

The deep ravine ("gill") formed by the small stream which flows by the village of Reighton, is cut quite through the Boulder-clay; and about half a mile below the village, beds of blue clay were found, yielding *Belemnites lateralis*, Phil., and many fragments of *Ammonites* and *Ancyloceras*. These beds are shown by their fossils to belong to the upper part of the Lower Neocomian (zone of *Ammonites speetonensis*).

From this point westward to the village of West Heslerton (see section, Pl. XXIII. fig. 2), a distance of fifteen miles, the base of the Wolds, as well as the bottom of the valley, is entirely covered and concealed by superficial deposits, and no opportunity is afforded for the study of the underlying strata. According to Young and Bird†, however, a boring one and a half mile south of Staxton showed, under 278 feet of white and red chalk, beds of blue clay or shale, which were pierced to the depth of 54 feet. The *general* dip of the strata being S.E., as we proceed westward the beds underlying the chalk gradually rise, and at length are seen at the base of the Wolds, above the great superficial deposits which fill the bottom of the valley.

In the western part of the parish of West Heslerton there were at one time several pits close to the Wold-foot, in which stiff blue clay was dug for dressing the loose sandy alluvial land of the district; these, however, have been closed for many years, and I could obtain no evidence of fossils having ever been found in them.

A little to the westward of these, however, on the boundary between the parishes of West Heslerton and Knapton, there is a pit to which great interest attaches. At the bottom of a very deep chalk-quarry the underlying clay has been dug for the purpose of dressing the land. The section exposed was as follows:—

* "The Hartford brook or river" (one of the tributaries of the Derwent) "rises on the very cliff near Filey, at a height of about 100 feet above the sea, and flows, westward, southward, and eastward, 100 miles before reaching it."—*Prof. J. Phillips*, 'Rivers, Mountains, and Sea-coasts of Yorkshire,' p. 85.

† 'Survey of the Yorkshire Coast,' p. 60 (1828).

(1) White chalk .... about 40 feet seen.
(2) Pale-red chalk, with red-clay partings. Crowded with specimens of *Belemnites minimus*, List. ... } thickness uncertain.
(3) Dark-blue clay, full of fossils.

According to the concurrent testimony of a number of reliable witnesses, this pit yielded immense numbers of beautiful *Ammonites*, mineralized by pyrites, with many *Belemnites*, and other shells, and was the source of the numerous fossils which found their way to the various Yorkshire museums and were labelled as Knapton fossils. From a consideration of all the evidence on the subject, I think there can be no doubt that this pit was opened in the highly fossiliferous zone of *Ammonites speetonensis*. The pit is now completely closed, and the bottom planted with trees.

A mile further to the west, and about half a mile south of the village of East Knapton, are found two other very interesting pits. The most easterly of these exhibits the following succession of beds :—

(1) Hard white chalk with a few flints.
(2) Red chalk, crowded with *Belemnites minimus*, List.
(3) Black shaly clay with dark-coloured septaria, containing numerous veins of calc-spar ; this clay was formerly dug to a very considerable depth.

In the clay itself, which is badly exposed at the present time, no fossils could be detected ; but in the septaria, thrown out from this pit when it was worked, numerous specimens of *Ammonites* were obtained. These were all Lower-Neocomian species, *Ammonites fascicularis*, D'Orb. (a shell known locally under the manuscript name of *A. evalidus*, Bean), being especially abundant. In my memoir on the Speeton section, I have not introduced this Ammonite into my lists, not having found it *in situ* ; but my friend Mr. Leckenby assures me that the numerous specimens of this shell in his own and other collections were all obtained from argillaceous nodules in the beds exposed at low water on Speeton shore, and but very little above the beds containing the Portlandian species.

In the second pit at Knapton, which is only about 100 yards to the westward of the former, we find the following beds :—

(1) Hard white chalk with a few flints.
(2) Light-red chalk full of *Belemnites minimus*, List.
(3) Dark-blue clays, very pyritous, containing many small brown fragments of ironstone.

This clay, from its pyritous character and long exposure to atmospheric influences, is now crowded with beautiful crystals of selenite. I could find no fossils here ; but if such originally existed in the beds, they must long since have perished, owing to the quantity of pyrites in the clay.

The most interesting circumstance, however, in connexion with this pit is, that at some little distance from the surface a layer of phosphatic nodules, about 6 inches thick, was discovered by the late Mr. Tyndall, of Knapton Hall. The value and importance of this discovery were not lost upon William Smith, who, then a resident

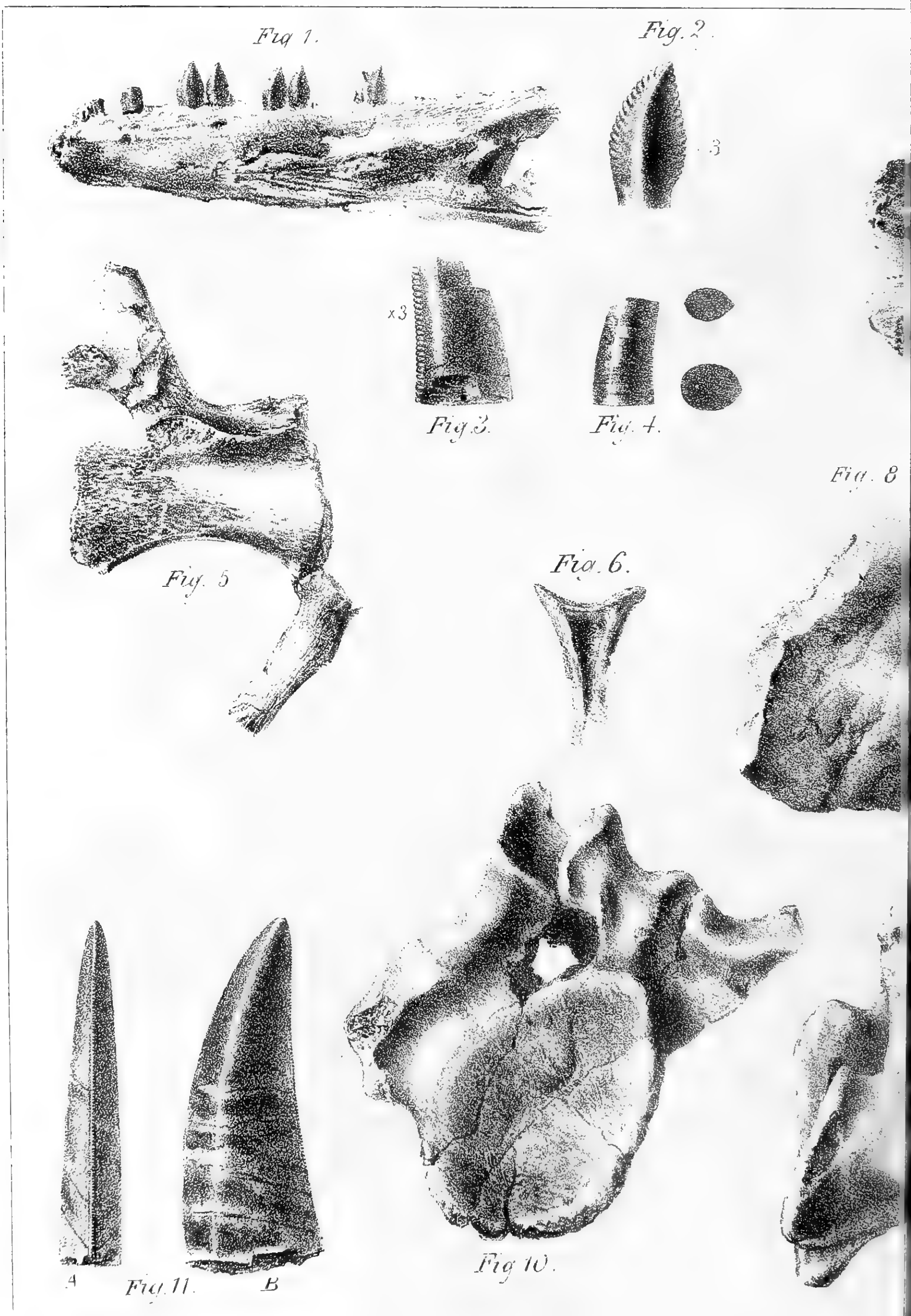


Fig 1.
Fig. 2.
3
x3
Fig 3.
Fig. 4.
Fig. 5
Fig. 6.
Fig. 8
Fig 10.
A
Fig. 11.
B

Fig. 7

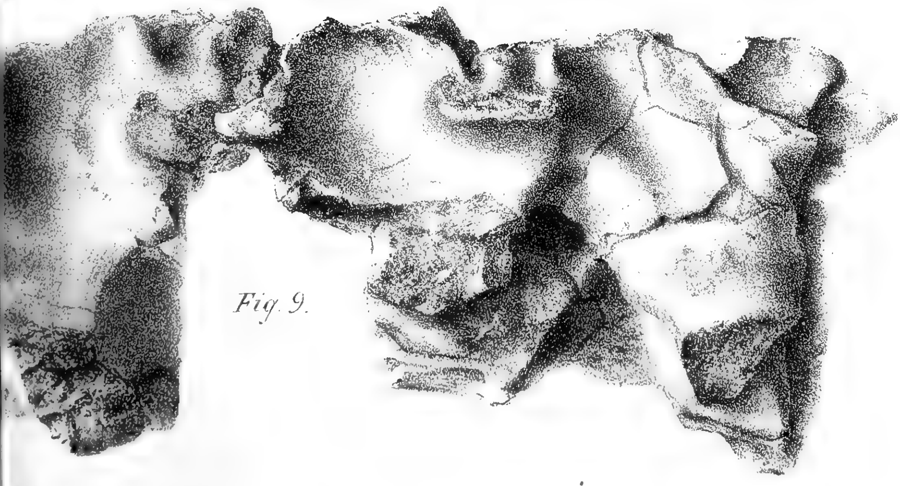


Fig. 9.

M & N. Hanhart imp.

NOSAURIA

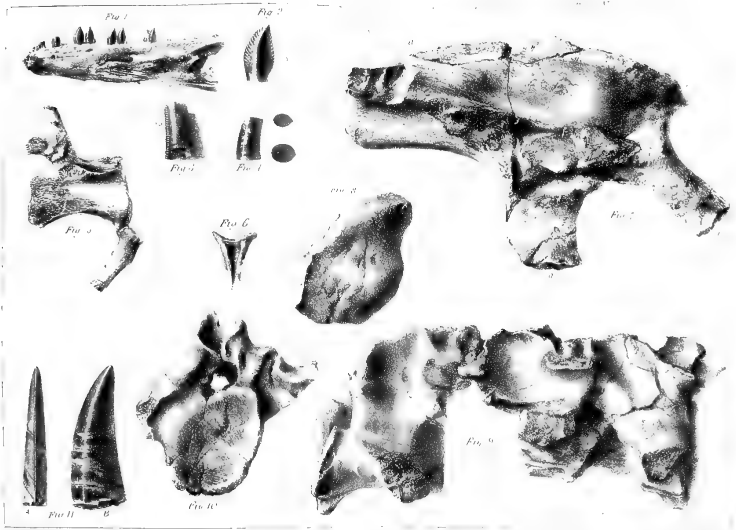


Fig 1
Fig 2
Fig 3
Fig 4
Fig 5
Fig 6
Fig 7
Fig 8
Fig 9
Fig 10
A
Fig 11
B

at Hackness, was a frequent visitor at Knapton; and experiments were conducted which demonstrated the great value of the material for agricultural purposes. Serious thoughts were at one time entertained of working this seam of phosphatic nodules; but its thinness and the amount of bearing which required to be moved in following the bed led to the abandonment of the scheme. I obtained specimens of these nodules; and they are identical in every respect with those which have of late years been so extensively worked at Speeton Cliff, and which, as shown by Mr. Leckenby, mark the boundary between the Neocomian and Jurassic formations. Taking into account the identity in character and thickness of this seam of phosphatic nodules with that worked at Speeton, the similarity in every respect of the pyritous clays in both localities, immediately overlying it, and the similar septaria in both, occurring at a little higher level and crowded with the same species of Ammonites, I think there can be no doubt that we have here at Knapton the junction of the Neocomian and Oolitic clays. At this place a boring was many years ago put down to the depth of 500 feet, the only strata pierced being beds of blue clay (Kimmeridge). It is quite in conformity with our views of the relations of the strata of the Vale of Pickering, that at Settrington and North Grimston, a little to the west of Knapton, we find the Kimmeridge clay lying immediately at the foot of the Wolds. The same formation is again found at several points along the north side of the Vale of Pickering, as at Kirkby Moorside, where *Ostrea deltoidea*, Sow., (which I have shown to be characteristic of the lowest Kimmeridge beds,) occurs. The clays of the two pits at Knapton were formerly dug for the purpose of supplying material to a brick-yard in the village, but they have not been worked for many years.

It will thus be seen that in their inland development the Upper and Middle Neocomian of Yorkshire have afforded no sections, the strata being covered by a great thickness of drift; of the Lower Neocomian, however, several of the beds are exposed inland at Reighton, West Heslerton, and Knapton; and at the last-mentioned place we observe the junction between the Neocomian and Jurassic beds. The relations of the strata of the Vale of Pickering are illustrated in the accompanying sketch map (Pl. XXIII. fig. 3), and in the section (fig. 2) drawn along the escarpment of the Wolds.

III. The Neocomian Iron-ores of Lincolnshire.

In 1867 I described the Middle Neocomian, or Tealby Series, of Lincolnshire as containing beds of valuable iron-ore. Since that date the West Yorkshire Coal and Iron Company have opened a mine near Acre House, between Claxby and Nettleton, and the expectations that I entertained of being able to obtain new light on the stratigraphical relations and the fossil-contents of these very interesting beds have been to some extent realized.

The existence in this district of fragments of iron-slag, calcined ore, and charcoal, associated with Roman pottery, indicates that these ores were known and worked at a very early period.

The only ironstone in this district which is now found suffi-

ciently rich to repay the working, is a rock almost entirely made up of small and beautifully polished oolitic grains of hydrated peroxide of iron. The earthy material, full of larger concretionary masses of ironstone, which was at first thought to be equally valuable, is found to yield so small an average percentage of iron that it is not worked. The oolitic ironstone rock is crowded with fossils, the shells of the gigantic *Pecten cinctus* being especially abundant; it also frequently exhibits veins of beautifully crystallized calcspar. The ore is thus an eminently calcareous one; it yields on analysis from 28 to 33 per cent. of metallic iron; in many places it appears to have undergone a certain amount of dehydratation, and exhibits irregular patches of dull reddish tints. The great value of this ore consists in its adaptability for smelting in admixture with the argillaceous ores of the coal-measures; and the whole of the rock at present raised is sent to Leeds for that purpose.

The useful bed of ironstone averages 6 feet 6 inches in thickness; it is mined by means of adits driven into the face of the hill: the working of this ironstone, however, is rendered less profitable, owing to the want of a good roof to the seam, and the consequent necessity for heavy timbering. The adits at the present time (December 1869) have extended for some 200 yards into the hill, and at the furthest point an upcast shaft, about 90 feet deep, has been put down. The ore is carried on a private railway, about $1\frac{1}{2}$ mile long, to the Holton-le-Moor station on the Manchester, Sheffield, and Lincolnshire Railway. For a considerable time past the ironstone has been raised and sent away at the rate of about 100 tons per day.

The ironstone beds are known to extend as far northwards as Hundon, where they are of considerable thickness; and a thin seam of the same rock has been found as far southward as Tealby.

The similarity in every respect of this ore with that which has been worked for many years at Steinlahde and Osterholz, near Salzgitter, and at some other points in Northern Germany is very striking. The German beds, which are among the various strata of somewhat different ages classed together by M. Fr. Ad. Römer as *Hilsconglomerat*, are, like the English strata, more or less completely made up of minute, polished, spherical, oolitic grains of hydrated peroxide of iron. The English and the German ironstones are, both as rock-specimens and in polished sections under the microscope, quite undistinguishable in their characters. The fossils also in the two cases are almost identical, and the extraordinary abundance and great size of the specimens of *Pecten cinctus* are in both alike remarkable. While, however, the English beds are almost horizontal, the German strata are greatly inclined (at Steinlahde at an angle of 63°), and can therefore be worked by means of great open pits. Similar oolitic ironstones to those of Lincolnshire and North Germany occur in the Neocomian of France and Switzerland*.

* The oolitic iron-ores mentioned by Dr. Fitton as occurring in the Lower Greensand of the Isle of Wight (Quart. Journ. Geol. Soc. vol. iii. pp. 302, 308) are very different from those we have been describing, consisting of grains of

COMPARATIVE TABLE OF THE NEOCOMIAN STRATA OF NORTHERN EUROPE.

	Yorkshire.	Lincolnshire.	Heligoland.	Holland.	Westphalia.	Hanover.	The Hartz.	Brunswick.
Gault. (Albien, *D'Orb.*)	Hunstanton red-rock.	Hunstanton red-rock.	Hunstanton red-rock.	?	Red Sandstones, with various Gault Clays, including the "Flammenmergel."	Gault Clays, including the "Flammenmergel" and Sands of the Lower Quader.	Gault Clays, including the "Flammenmergel" and Sands of the Lower Quader.	Gault Clays, including the "Flammenmergel."
	U N C O N F O R M I T Y.				U N C O N F O R M I T Y.			
Upper Neocomian. (Aptien, *D'Orb.*; Rhodanien and Aptien, *Renev.*)	? feet. Black clays, Dark blue clays ...... 120 "Cement-beds" 30	Upper Sands?	Absent.	?	Upper Ironshot Sandstones of Ochtrup, &c. Clays of Ahaus, &c.	"Hilssandstein"? Upper part of the "Hilsthon."	"Subhercynischer Unter-Quader." ? Clays of Olhey, &c.	Whitish marly clays ("Gargas-Mergel," Von Stromb.). Dark-coloured clays ("Zone of *Am. Martini*," Von Stromb.). Dark blue unfossiliferous clays.
Middle Neocomian. (Urgonien, *D'Orb.*; Barrémien and Urgonien, *Coq.*)	Dark blue clays, with few fossils .... 80 ("Zone of *Pecten cinctus*.") Blue clay with fossils ...... 40 ("*Ancyloceras*-beds.") Clays with septaria 30	"Tealby Series." Clays, limestones, and oolitic ironstones. With many fossils.	Absent.	Yellow Ironshot Sandstones of Losser.	Dark clays with *Bel. jaculum*. Calcareous sandstones of Bentheim, and the Teutoburger Wald, with clays and oolitic ironstones.	Lower part of the "Hilsthon." Oolitic ironstones of Steinlahde, the Osterwald, the Hils, &c. "Hilsconglomerat" (in part).	Clays, limestones, sands, and oolitic ironstones of the North foot of the Hartz.	Dark blue tenacious clay ("Speeton-Thon," Von Stromb. Dark blue clays ("Zone of *Crioceras Emmerici*," Von Stromb.). Unfossiliferous clays. Beds of clay, with *Exogyra sinuata* ("Zone of *O. Couloni*, var. *aquila*," Von Stromb.).
Lower Neocomian. (Néocomien, *D'Orb*; Valanginien and Néocomien, *Desor.*)	Blue clays .... 100 ("Zone of *Am. speetonensis*.") Blue clays .... 50 ("Zone of *Am. noricus*.") Blue pyritic clays .... 50 ("Zone of *Am. Asterianus*.")	Lower Sands and Sandstones?	"Töck." Black bituminous clays ("Zone of *Am. speetonensis*"). Absent.	?	F R E S H W A T E R S T R A T A (The North-German Wealden).	Elligser Brinke Schist.		Unfossiliferous clays. Limestones and sandy marls full of fossils. "Hilsconglomerat" (in part).
Tithonian, *Oppel.*	U N C O N F O R M I T Y.							UNCONFORMITY?
Jurassic.	Portlandian Clays, &c.	Kimmeridge Clay.	Oxfordian.	?	"Weisse Jura" = Portlandian and Kimmeridgian.			

To face p. 331.]

BLE OF THE NEOCOMI

	Yorksh	Holland.
Gault. (Albien, *D' Orb.*)	Hunstanton ck.	?
Upper Neocomian. (Aptien, *D' Orb.*; Rhodanien and Aptien, *Renev.*)	? Black clays Dark blue clays " Cement-beds "	?
Middle Neocomian. (Urgonien, *D' Orb.*; Barrémien and Urgonien, *Coq.*)	Dark blue clays, fossils .... (" Zone of *Pe* Blue clay with fos (" *Ancylocera* Clays with septari	Yellow Ironshot Sandst of Lösser.
Lower Neocomian. (Néocomien, *D' Orb*; Valanginien and Néocomien, *Desor.*)	Blue clays .... ainous (" Zone of *Am.* s *spee-* Blue clays ..... (" Zone of *Ar* Blue pyritic clays (" Zone of *An*	?
Tithonian, *Oppel.*		
Jurassic.	Portlandian Clays	?

The various sections obtained in the Acre-House Mine show that the thickness and order of succession of the different beds change very rapidly within short distances. The upcast shaft gave the following section from above downwards:—

		ft.	in.
(1)	Soil	2	6
(2)	White chalk .... 9 to	10	0
(3)	Beds of yellow clay and red marly chalk	10	0
(4)	Red sand	10	0
(5)	Limestone rock, hard- and blue-hearted	14	0
(6)	Blue clay, with the same fossils as the limestone above (*Pecten cinctus* abundant)	40	0
(7)	Ironstone, soft and earthy above, solid and finely oolitic below (only the lower part is worked) .... 13 to	14	0
(8)	Coarse greenish-white sands, in places indurated into hard sandstone-rock .... 6 to	7	0
(9)	Very dark-coloured, highly bituminous, shaly clay. A thin bed at the top is remarkable for its highly inflammable character, and greatly resembles the Kimmeridge coal of the south of England.		

In this section, 3 evidently represents the Hunstanton Red-rock (Gault?); 4, the upper sands (Upper Neocomian?); 5, 6, and 7, the Tealby series (Middle Neocomian); 8, the lower sand and sandstone (Lower Neocomian?); and 9, the top beds of the Kimmeridge Clay.

The most interesting point about the above section is the great thickness of the clays 6, which in their mineralogical characters and fossil contents precisely resemble those of the Middle Neocomian at Speeton Cliff. As we proceed southwards the clays evidently become much thinner and subordinate to the limestones, while these last, on the other hand, are very extensively developed*.

IV. General Sketch of the Neocomian Beds of the North of England.

The most striking and remarkable circumstance in connexion with the stratigraphical position of the beds of Mesozoic age in Yorkshire and Lincolnshire, and that which it is always necessary to bear in mind in reasoning on their relations, is the *grand unconformity* which exists between the Cretaceous and Neocomian series (see section, fig. 2, and Table, p.331*). In consequence of this the chalk beds overlap all the Neocomian and Jurassic beds in succession quite down to the Lower Lias. Thus the Hunstanton Red-rock (the base of the Upper Cretaceous) is found lying in succession on Upper Neocomian at Speeton, on Lower Neocomian at West Heslerton, on Portlandian (?) at Knapton, on Kimmeridge clay at North Grimston, on Coralline Oolite at Leavening, and on Inferior Oolite at South

sand, each of which is coated with peroxide of iron, while the grains of the Lincolnshire and German ores are almost entirely made up of concentric coats of the last-mentioned substance.

* For much information concerning these Lincolnshire ores I am indebted to W. Firth, Esq., of Leeds, the Managing Director of the Yorkshire Coal and Iron Company.

Grimston. Between this last point and Sancton, the red-rock overlaps successively the different members of the Lias, and at the last-mentioned place, the representative of the Inferior Oolite, now reduced to a very thin bed, is again uncovered. As we approach the Humber, the Kelloway, the Oxford, and the Kimmeridge successively reappear from beneath the Chalk; and crossing into Lincolnshire we recover the Lower (?) Neocomian at Worlaby, the Middle Neocomian at Clixby, and the Upper (?) Neocomian at Nettleton Hill.

It is this circumstance of the overlap of the Upper Cretaceous beds, combined with that of the Neocomian strata dipping at a high angle, which has caused these latter to occupy so small an area in Yorkshire.

At Speeton Cliff we have upwards of 500 feet of Neocomian clay exposed, although the upper part of the series is not here complete.

Of the *Upper* Neocomian clays (above 150 feet thick) with the well-defined zone of the cement-beds, containing the remarkable fauna so exactly agreeing with that of the Atherfield clay of the South of England, no trace is discoverable inland, as they are completely covered up by the great drift-deposits of the Vale of Pickering.

The same is true of the *Middle* Neocomian (also 150 feet thick) with its well-defined fauna, marked especially by the abundance of the gigantic *Pecten cinctus* and the bands with numerous specimens of *Ancyloceras* towards its base.

Of the *Lower* Neocomian (200 feet thick) we obtain, however, distinct traces inland. After a very imperfect reappearance in Reighton Gill, only a mile from the cliff section (fig. 2), the uppermost beds (zone of *Ammonites speetonensis*) are quite lost under the drift for a distance of fifteen miles; they are then seen again at West Heslerton, when on the very point of disappearing under the chalk in consequence of the overlap. The lowest beds of the Lower Neocomian are also found at Knapton, when about to be similarly lost under the Wolds.

The Neocomian beds, which thus disappear at Knapton, are entirely concealed from us by the overlapping Chalk strata for a distance of over forty miles (see Map, Pl. XXIII. fig. 3). In this space they have undergone considerable changes both in thickness and mineralogical characters; but the several subdivisions are still recognizable by means of their characteristic fossils.

We have seen that the whole series of these beds in Yorkshire consists entirely from top to bottom of clays, varying, it is true, in such merely accidental characters as colour, amount of pyrites, the number and nature of the enclosed septaria, and the abundance and state of mineralization of their fossils. When, however, the Neocomian beds first reappear at Worlaby, in Lincolnshire, it is in the form of a coarse, greenish-white sand, in places passing into a hard sandstone. The deficiency and bad state of preservation of the fossils in these beds, which occupy the base of the Wolds from Worlaby to Clixby, prevents us from certainly deciding as to their place in the series. It is possible that they represent in a very

reduced and altered form the 200 feet of clay forming the Lower Neocomian of Speeton; it may be, however, that they are only to be regarded as a subordinate bed of the Tealby Series, in which case the Lower Neocomian must have entirely thinned out and disappeared in the forty miles which intervene between Knapton and Worlaby.

Near Clixby reappear beds from beneath the Chalk which more nearly resemble their equivalents in Yorkshire. These are blue clays containing large numbers of *Pecten cinctus*, *Ancyloceras*, and other fossils, but which differ from the Yorkshire Middle Neocomian by being interstratified with subordinate beds of yellow sandy limestone and oolitic ironstones. As we proceed southwards, these latter beds become thicker and of greater relative importance, till at Tealby, Willingham, and Hainton, the ironstones having gradually disappeared, the clays become greatly diminished, and the limestones proportionately increased, the formation assumes, over a small area, an essentially *calcareous* character. As we still proceed southwards, however, we find this limestone formation gradually diminishing in thickness, and finally disappearing altogether.

The highest Neocomian beds, and those which reappear last from beneath the Lincolnshire Wolds, have assumed the arenaceous character which prevails in them throughout this country. Instead of blue clays, they consist of white or brown almost unfossiliferous sand and sandstone. These beds are persistent long after the lower portions of the series have disappeared, and, stretching southwards, pass into Norfolk, where they are known as the "Carstone," and contain at their base, as shown by Mr. Wiltshire *, the characteristic fossils of the Upper Neocomian.

Still further southwards occur the thin and anomalous but highly interesting fossiliferous deposits of Upware and Potton, which appear to form the link between the Neocomian deposits of the north and south of England.

V. Results of a General Comparison of the Neocomian Beds of Northern Europe.

Small as is the area occupied by the Neocomian strata now exposed in the North of England, there is abundant evidence that beds of this age were originally deposited to a great thickness over a very wide area in Northern Europe. A concurrence, however, of accidental circumstances (namely, the overlap of the Upper Cretaceous, the great spread of diluvial deposits over North-western Europe, and, finally, the great breach in the land formed by the North Sea) have caused the representatives of the Neocomian to be reduced to a few comparatively small and isolated patches.

Unlike their English equivalents, the continental beds are frequently much disturbed and even contorted, and the Neocomian strata usually form narrow strips along the flanks of hill-chains, the wide plains between which are covered with the widely spread

* Quart. Journ. Geol. Soc. vol. xxv. p. 189 (1869).

"diluvial sand with boulders." The exposures of the beds in question over this area are usually of a very limited character, and are almost entirely confined to such accidental openings as stone-pits and brickyards, while nowhere does any such key to the relations of the beds occur as that which is afforded by the grand cliff-section of Yorkshire. Owing to these causes the geologists of North Germany have been reduced, in the classification of their Neocomian strata, to rely, almost solely, upon palæontological evidence, especially upon that obtained by comparison with the typical beds of the same age in Switzerland. An examination of the results thus arrived at, side by side with those obtained by the study of the very similar and much more favourably exposed beds of the North of England, while it, on the whole, confirms the views now generally held by Continental geologists, yet suggests some modifications of those views, of considerable interest and importance.

It is not my intention to attempt any thing like a general description of the Neocomian formation in Northern Germany; this subject has been already most admirably treated in the works of Fr. Ad. Römer, Geinitz, Ferd. Römer, Beyrich, Ewald, and especially of von Strombeck. What I propose is, to show the relations of the various strata of this age in Northern Europe with those in the northern parts of this country. To qualify myself for this task I have visited nearly all the most typical sections in North-western Germany, and have examined all the public and many of the private collections of fossils in that district; and it is with much pleasure that I take the present opportunity of acknowledging the great amount of kind assistance which I received from several distinguished German geologists, among whom I may especially mention M. von Strombeck, of Brunswick, M. Hermann Römer, of Hildesheim, and M. Witte, of Hanover.

1. *Heligoland.*—We have seen that at Speeton the Neocomian strata, even before their full emergence from beneath the overlapping Chalk strata, are cut off by the denuding action of the North Sea. Intermediate between this section and those of North Germany, an important and extremely interesting link is afforded by the beds exposed in the little island of Heligoland, which is rapidly wasting away beneath the waves of the German Ocean. The strata in question are exposed, not in the cliffs of the present island, but in certain banks, visible only at low water, about a small islet which is said to have been separated from the main island within historical times. The beds appear to be inclined at a considerable angle; and their succession is as follows:—

(1) White Chalk, containing a large series of fossils, agreeing precisely with those of the Lower Chalk of Yorkshire and Lincolnshire.
(2) Variable beds of "rust-yellow and yellowish red chalk or limestone," some of which become more or less sandy, containing *Belemnites minimus*, List.
(3) Blackish-blue pyritous clays (called *Töck*), containing many fossils mineralized by iron pyrites.
(4) Beds with Oxfordian fossils, followed by others with Lias fossils.

The agreement of these strata with certain portions of the Yorkshire series is very striking and remarkable. The bed 2 is shown, by its petrological characters, its stratigraphical relations, and its characteristic fossil to be the " Hunstanton Red-rock."

The *Töck* (3) is very fossiliferous. The following is a list of the species which have been recorded from it, excluding the doubtful ones (founded on the small fragments of *Ancyloceras*, which are very numerous here *).

Belemnites jaculum, *Phil.*
—— lateralis, *Phil.*
Ammonites speetonensis, *Y. & B.*
—— ——, var. venustus, *Phil.*
—— ——, var. concinnus, *Phil.*
—— Nisus, *D' Orb.*
—— rotula, *Sow.*
Ancyloceras (Crioceras) Duvali, *Lév.*
Ancyloceras (Crioceras) Emmerici, *Lév.*
—— (Crioceras) Puzosianus, *D' Orb.*
—— (Hamites) raricostatus, *Phil.*
Thracia Phillipsi, *Röm.*
Pholas constricta, *Phil.*
Serpula Phillipsi, *Röm.*
Rhynchonella nuciformis, *Sow.* sp. ?
Fish-remains.

On a comparison of this list with that given in my paper on the Speeton Clay †, it will be found that of the fourteen forms twelve occur in our " zone of *Ammonites speetonensis*," some of them being *highly characteristic* of that zone. *Serpula Phillipsi* occurs in the beds immediately above those with *Am. speetonensis* at Speeton; but in my personal searches (on which alone the lists are based) I did not succeed in finding it lower down in the series; in Germany, however, this fossil certainly ranges downward to the bottom of the Neocomian. Concerning the fossil called *Terebratula nuciformis*, Sow., by Prof. Wiebel, I feel much doubt, but would suggest that it may not improbably be the *Rhynchonella Renauxiana* of D'Orbigny.

From the conclusive evidence just adduced, there cannot, therefore, be any doubt that in the little island of Heligoland (a mere speck in the German Ocean) we have, preserved in a very remarkable manner amid the general destruction of the strata of this area, most interesting vestiges of the " Hunstanton Red-rock," and of the " zone of *Ammonites speetonensis* " of the Yorkshire series. The relation of these in the island of Heligoland is precisely the same as in the pit above described at West Heslerton. Heligoland is situated 325 miles due east of Speeton, and 150 miles from the nearest exposure of the Neocomian beds on the Continent.

2. *Holland.*—Although this country is now almost completely covered with drift and alluvial deposits, I found in the great Museum of Natural History at Leyden, interesting evidences of the former wide extension of the Neocomian strata. Among the large collections of boulders in that museum are a number composed of a peculiar yellow limestone, precisely similar to that of Tealby, and in some cases enclosing specimens of the highly characteristic *Pecten cinctus.* Boulders of the same material are not rare in the

* *Vide* Fr. Ad. Römer, Verst. nordd. Kreidegeb. (1841). Wiebel, Die Insel Helgoland (Hamburg, 1848).

† Quart. Journ. Geol. Soc. vol. xxiv. p. 235.

eastern counties of England; and it was from a block of this kind in Suffolk that one of Sowerby's type specimens of *Pecten cinctus* was obtained.

According to Murchison and Nicol's Geological Map of Europe (1856), Cretaceous strata containing *Perna Mulleti* and *Crioceras Duvali* occur at the village of Lösser, near to Oldensaal, on the western borders of Holland. These beds have been described by M. Ferd. Römer *, to whom the fossils collected at Lösser have been submitted by the General Commission for the Geological Examination of the Netherlands. Under a thin covering of the sandy drift, which completely masks all the country around, is found a bed of yellow ironshot sandstone, very similar to that of the Teutoburger Wald, and containing the following fossils, which enable us to refer it, without doubt, to the *Middle* Neocomian:—

Ammonites Decheni, *Röm.* (A. bidichotomus, *Leym.*, junior).	Lima longa, *Röm.*
Ancyloceras (Crioceras) Duvali, *Lév.*	Lima, sp. (the same that is abundant at Gildehaus).
Exogyra sinuata, *Sow.*	Trigonia, sp.
Pecten cinctus, *Sow.*	Pholadomya, sp.
Perna Mulleti, *Desh.*	Goniomya, sp.
Pinna (the same species as in the Teutoburger-Wald Sandstone) near to *Pinna Neptuni*, D'Orb.	Heteropora ramosa, *Röm.*

3. *Westphalia.*—Passing eastwards we find the first exposures of the Neocomian of North-western Germany in the hill-group of Bentheim. Here the formation is represented by beds of yellowish grey sandy limestone, very similar to that of Tealby, which passes insensibly into hard sandstones, and in places contains thick beds of blue clay. These beds and the similar ones of the Teutoburger Wald were formerly classed with the Quader; the settlement of the question of their true age is due to Professor Ferd. Römer †. The list of the fossils which he gives, from Gildehaus, near Bentheim, shows that these limestones, like those of Lincolnshire, are referable to the *Middle* Neocomian. The following is the list:—

Crioceras Duvali, *Lév.*	Avicula Cornueliana, *D'Orb.*
Belemnites lateralis, *Phil.*	Lima, sp.
Panopæa neocomiensis, *Desh.* sp. (large form).	Pecten cinctus, *Sow.*
	—— orbicularis, *Sow.*
Thracia Phillipsi, *Röm.*	Exogyra sinuata, *Sow.*

The Neocomian strata stretch in a band, running in an easterly direction from Bentheim to a point on the Ems, between Rheine and Salzbergen. At the eastern end of this band the beds pass into black clay full of septaria.

In the same district, but considerably to the south, near Ahaus, there occur black plastic clays, containing a bed, a little over one foot thick, of pyritous argillaceous stone, containing the following fossils:—

* Zeitschrift d. deutsch. geol. Gesell. vi. (1854) p. 124.
† Neues Jahrb. für Min. u. s. w. 1850, p. 385.

Belemnites brunswicensis, *Von Stromb.*
Ammonites Deshayesi, *Leym.*
—— Martini, *D' Orb.*
——, sp.
——, sp.
Crioceras ? sp.
Ancyloceras gigas, *Sow*, sp. (A. Renauxianus, *D' Orb.*).
Panopæa neocomiensis, *D' Orb.*
Pinna Robinaldina, *D' Orb.*
Avicula, sp.
Terebratula Moutoniana, *D' Orb.*
Megerlia tamarindus, *Sow.* sp.
Rhynchonella antidichotoma, *Buv.* sp.
—— Gibbsiana, *Sow.*
Terebratella Astieriana, *D' Orb.*
Holaster lævis, *Ag.*
? Hemiaster phrynus, *Desor.*
Species of Rostellaria, Pleurotomaria, Inoceramus, &c.

This fauna enables us to refer this bed with certainty to the *Upper* Neocomian.

The succession of beds described by M. Hosius * as occurring at Ochtrup, intermediate between Bentheim and Ahaus, enables us to bring into connexion the sandstones of the former place with the clays of the latter.

Under Gault clays, abounding with *Belemnites minimus*, List., we find :—

(1) Iron sandstone without fossils.
(2) Clays with septaria, and hard bands containing :—

Ancyloceras gigas, *Sow.* sp. (A. Renauxianus, *D' Orb.*).
—— Matheronianus, *D' Orb.*
Ammonites Deshayesi, *Leym.*
—— Martini, *D' Orb.*
Belemnites brunswicensis, *Von Stromb.*

These beds are evidently the same as those of Ahaus, i. e. *Upper* Neocomian, and on the same horizon as the " Cement-beds " of Speeton.

(3) Clays containing *Belemnites jaculum*, Phil., abundantly, and *Bel. brunswicensis*, Von. Stromb., rarely. These beds correspond with the upper part of the Middle Neocomian of Speeeton.
(4) Unfossiliferous clays.
(5) Sandstones, sometimes coarse and quartzose, and at other times ironshot. From these no fossils are recorded, but they are probably the same as those of Gildehaus. They lie directly upon
6) The " Wälderthon."

Along the Teutoburger Wald, from Ibbenbuhren to Bielefeld, the beds of yellowish-brown sandstone, like those of Bentheim, and of considerable thickness, frequently form the highest point of the chain. These beds at times pass into limestones and ironstones and are associated with thick beds of blue clay. Everywhere they appear to be characterized by the abundance of large specimens of *Pecten cinctus*, Sow. The same strata occur similarly in the range of the Lippischer Wald, which forms a continuation of the Teutoburger Wald in a south-easterly direction, and in the chain of the Egge Gebirge, which from the former runs in a southerly direction from Detmold to near Warburg †.

From the Sandstones of the Teutoburger Wald the following fossils have been recorded, which clearly indicate their identity with the similar strata of Gildehaus and Lösser, and that, like these, they are to be referred to the same horizon as the Tealby Limestones and the middle portion of the Speeton Clay.

* Beiträge zur Geognosie Westphalens, Zeitschr. d. deutsch. geol. Gesell. xii. (1860) p. 48.

† *Vide* Ferd. Römer, Leonh. und Bronn's Jahrb. 1845, p. 267; 1850, p. 385; 1852, p. 185; also Zeitschr. d. deutsch. geol. Gesell. vi. 1854, p. 99, &c.

Belemnites lateralis, *Phil.*
Nautilus pseudo-elegans, *D'Orb.*
Ammonites bidichotomus, *Leym.*
—— Decheni, *Röm.* (A. bidichotomus *junior*).
—— noricus, *Schloth.*
—— Gervilianus, *D'Orb.*
——, sp.
Ancyloceras grande, *Sow.* sp.
—— (Crioceras) Emmerici, *Lév.*
—— (Crioceras) Duvali, *Lév.*
Pleurotomaria Fittoni, *Röm.*
Ostrea macroptera, *Sow.*
Exogyra sinuata, *Sow.* (A. aquila, *Brong.*).
Pecten cinctus, *Sow.*, very abundant.
—— orbicularis, *Sow.*
—— muricatus, *Goldf.*
—— atavus, *Röm.*
Inoceramus lobatus, *Münst.*
Perna Mulleti, *Desh.*
Gervillia anceps? *Desh.*
Avicula Cornueliana, *D'Orb.* (A. macroptera, *Röm.*).
——, sp.
Pinna gracilis, *Phil.* (P. rugosa, *Röm.*).
Lima moreana, ? *D'Orb.*
——, sp.
Modiola reversa, *Sow.*
Arca exaltata, *Nilss.*
—— glabra, *Sow.*
—— concentrica, *Röm.*
Pectunculus umbonatus, *Sow.* (P. decussatus, *Röm.*).
Cardium, sp.
Isocardia neocomiensis, *D'Orb.* (Ceromya neocomiensis, *Ag.*).
Trigonia pulchella, ? *Reuss.*
—— divaricata, *D'Orb.*
—— rudis, *Park.*
Thetis Sowerbyi, *Röm.*, var. major, *Sow.*
Thetis Sowerbyi, var. minor, *Sow.*
Thracia Phillipsi, *Röm.*
—— elongata, *Röm.*
Panopæa Römeri, *Gein.*
—— plicata, *Sow.*
—— mandibula, *Sow.*
Pholadomya elongata, *Münst.* (P. gigantea, *Sow.*).
—— alternans, *Röm.*
—— designata, *Goldf.*
—— nodulifera, *Münst.*
Anatina Cornueliana, ? *D'Orb.*
Waldheimia celtica, *Mor.* (Ter. longa, *Röm.*).
Terebratula prælonga, *Sow.* (T. biplicata, var. acuta, *Von Buch*).
Rhynchonella multiformis, *Röm.*
Lingula truncata, *Sow.* = L. Meyeri, *Dunker.*
Diadema, sp. (very rare).
Holaster lævis, *Röm.*
Toxaster complanatus, *Ag.* (one specimen).
Heteropora ramosa, *Dunk. & Koch.*
Ceriopora (Alveolites) tuberosa, *Röm.*
Eschara, sp.

4. *Hanover.*—Passing over a considerable area in which no exposure of Neocomian beds is found (with the exception of a clay near Minden, abounding with *Thracia Phillipsi*, Röm.), we come into Hanover, the native country of M. Fr. Ad. Römer, and that in which these strata were most fully described and illustrated by him, under the names of "Hilsthon" and "Hilsconglomerat"*. More recently, the strata of this country have been mapped by his brother, M. Hermann Römer.

The Neocomian beds of Hanover are chiefly exposed on the flanks of the various hill-chains of the country (which rise above great plains covered with drift), as the Deister, the Lindener Berg, the Osterwald, the Suntel, and especially the Hils, from which latter the beds take the name by which they are most generally known in Northern Germany.

Throughout Hanover, the Neocomian is usually represented by thick beds of blue clay (Hilsthon) which, however, locally pass into oolitic ironstones and sandstones. The upper part of these clays

* The name "Hilsconglomerat" was applied to a number of strata of somewhat different ages, viz.:—1. the Greensand of Essen or the Tourtia (of Upper Greensand age?); 2. the ironstones of Steinlahde, the Osterwalde, &c. (Middle Neocomian); 3. the Lower Neocomian Limestones &c. of Brunswick.

contains an eminently *Aptian* or *Upper*-Neocomian fauna, including *Ammonites Deshayesi*, Leym., *A. Martini*, D'Orb., *Am. Nisus*, D'Orb., &c.; while the lower portion contains a fauna which is as unmistakably that of the *Middle* Neocomian, comprising *Pecten cinctus*, Sow. (of large size and in great abundance), *Ammonites clypeiformis*, D'Orb., *Thracia Phillipsi*, Röm., *Serpula Phillipsi*, Röm., *Meyeria ornata*, Phil. sp., and *Terebratula hippopus*, Röm.

The *Upper* Neocomian beds do not appear to be generally well exposed in this country, and only a small fauna has, as yet, been recorded from them; the *Middle* Neocomian, on the other hand, is admirably exhibited at a number of different points, and has yielded a large and very interesting series of fossils.

A few years ago a canal, which passed along the base of the Lindener Berg, about a mile from the town of Hanover, very well exposed the Middle Neocomian beds of the Hilsthon, the fossils of which were collected by M. Witte. Among these fossils I was able to identify the following:—

Ammonites clypeiformis, *D'Orb.*
—— marginatus, *Phil.*
—— rotula, *Sow.*
—— Nisus, *D'Orb.*
Pecten cinctus, *Sow.*
Pholadomya alternans, *Röm.*
Lima (several well-known Speeton forms).
Thracia Phillipsi, *Röm.* (very large).
Terebratula hippopus, *Röm.*
Meyeria ornata, *Phil.*, sp. (very abundant).

To the south-west of the town of Hanover, along the northern foot of the Deister, the lower beds of the Hilsthon are again well exposed. They rest directly upon the "Wälderthon," and consist of greyish-blue clays (from 60 to 70 feet thick), full of septaria of a greyish-brown colour, and nodules of pyrites. At Bredenbeck, in this district, the following large and interesting fauna has been found:—

Belemnites lateralis, *Phil.*
Ammonites concinnus, *Phil.*
—— Phillipsi, *Röm.* (?).
—— multiplicatus, *Röm.*
—— marginatus, *Phil.*
—— nucleus, *Phil.* (?)
—— noricus, *Schloth.*
—— curvinodus, *Phil.* (?)
—— radiatus, *Brug.* (A. asper, *Merian*).
—— Gervilianus, *D'Orb.*
Ancyloceras (Crioceras) Emmerici, *Lév.*
Auricula striata, *Röm.*
Panopæa plicata, *Sow.*
Pleuromya solenoïdes, *Röm.*
Thracia Phillipsi, *Röm.*
Cucullæa Schusteri, *Röm.*
Pholas constricta, *Röm.*
Modiola pulcherrima, *Röm.*
Avicula pectinata, *Sow.*
Pecten cinctus, *Sow.*
—— orbicularis, *Sow.* (P. laminosus, *Münst.*).
—— striato-punctatus, *Röm.*
Palæmon (?) dentatus, *Röm.*
Meyeria ornata, *Phil.* sp.
Pollicipes radiatus, *Röm.*
Serpula quinquecarinata, *Röm.*
—— antiquata, *Röm.*

Southwards from the Deister the same beds, under somewhat different conditions, are again exposed in the Osterwald. We find these blue clays of the usual character, containing the following fossils:—

Ammonites clypeiformis, *D'Orb.*
Modiola rugosa, *Röm.*
Pholas constricta, *Röm.*
Pholadomya alternans, *Röm.*
Lyonsia (?) elongata, *Reuss.*

At this place, however, the clays are associated with beds of limestone and coarse sand, passing into oolitic and conglomerate ironstones. These beds have yielded the following fossils.

Pycnodus Hartlebeni, *Röm.*
Meyeria ornata, *Phil.* sp.
Serpula angulosa, *Röm.*
Belemnites lateralis, *Phil.*
Ammonites bidichotomus, *Leym.*
Nautilus, sp.
Turbo clathratus, *Röm.*
Exogyra sinuata, *Sow.*
Pinna gracilis, *Phil.* (P. rugosa, *Röm.*).
Avicula Cornueliana, *D'Orb.* (A. macroptera, *Röm.*).
Modiola rugosa, *Röm.*
Thetis Sowerbyi, *Röm.*
Thracia Phillipsi, *Röm.*
Panopæa Römeri, *Gein.*
Pholadomya alternans, *Röm.*
Rhynchonella.

Very similar to those of the Osterwald are the beds exposed at several points in the valley of the Inner, especially at Steinlahde, near Salzgitter, where the ironstone has for a long time past been extracted by means of a great open working. The section seen here is as follows, the beds dipping E. 63°.

(1) *Flammenmergel* (Gault), with the usual characters, light-coloured and variegated clays, curiously striped (fancifully supposed to resemble flames, hence the name) .... 20 feet seen.
(2) Variegated purplish-red, yellow, and bluish clays, with several irregular layers (each about 6 inches thick) of argillaceous limestone. Through these beds fragments and oolitic remains of ironstone are disseminated, but sparingly... 40 feet.
(3) Ironstone conglomerate, made up of irregular nodules of various sizes and of perfectly round and beautifully polished oolitic grains of brown ironstone. The bed is crowded with fossils, the gigantic *Pecten cinctus* being especially abundant.. 15 feet.
(4) Light-brown calcareous sandstone (resembling that of Lincolnshire), containing enormous numbers of *Pecten cinctus*, *Exogyra sinuata*, and other fossils. .... Thickness 10 to 25 feet.
(5) Variegated clays similar to 2.

The beds in this neighbourhood are evidently very variable in character. A shaft sunk near the mine exhibits very pyritous blue clays, with many bands of argillaceous limestone, covered by beds of white sand and sandy limestone. The oolitic ironstones, with precisely similar characters to those of Steinlahde, are also dug at some other points in the neighbourhood of Salzgitter, as at Osterholz. These ironstones yield the following fossils, which enable us to refer the beds with certainty to the horizon of the Middle Neocomian. We have already pointed out the striking similarity, both in mineral character and fossil contents, of these beds to those of our Tealby series.

Belemnites jaculum, *Phil.*
—— lateralis, *Phil.*
Ammonites bidichotomus, *Leym.*
——noricus, *Schloth.*
Ancyloceras (Crioceras) Emmerici, *Lév.*
Nautilus radiatus, *Sow.*
Exogyra sinuata, *Sow.*
Pecten cinctus, *Sow.*
Panopæa neocomiensis, *Desh.*, sp.
Terebratula hippopus, *Röm.*
—— sella, *Sow.*

It is interesting to notice that the Flammenmergel (the representative of the Gault) appears, at Steinlahde and at some other points,

to rest directly upon the Middle Neocomian beds. This fact, taken in conjunction with that of the Neocomian being so frequently overlapped by the beds of the Upper Cretaceous, appears to point to the conclusion that in Northern Germany, as in this country, an unconformity exists between the two series.

In the low land in the neighbourhood of Hildesheim the clays of the Middle Neocomian again occur, but are only exposed in a few clay-pits. In these I collected:—

Ancyloceras (Crioceras) Emmerici, *Lév.*
Belemnites jaculum, *Phil.*
Exogyra sinuata, *Sow.*
Pecten cinctus, *Sow.*
&c. &c.

In the chain of the Hils the deposits of Neocomian age are very well developed. The locality of Elligser Brinke, near Delligsen, is especially celebrated—the beds here, which were at first referred to the Jurassic System (Oxfordian and Kimmeridge), having yielded a very large suite of fossils, particularly rich in Brachiopoda and Sponges.

I found the beds at this place to consist of blue clays, with a few septaria of a whitish colour, and also some scattered irregular nodules of brown ironstone. At a considerable depth in this clay occurs a bed (not now exposed) of argillaceous limestone, crowded with oysters, brachiopods, and other shells *. The following fossils have been obtained from Elligser Brinke, the beds at which place appear to represent the lowest portion of the Middle Neocomian, or the top of the Lower Neocomian.

Belemnites lateralis, *Phil.* (B. subquadratus, *Röm.*).
—— jaculum, *Phil.* (B. pistillum, *Röm.*).
Nautilus radiatus, *Sow.*
Ammonites noricus, *Schloth.*
—— radiatus, *Brug.* (A. asper, *Merian*).
—— clypeiformis, *D'Orb.*
Pleurotomaria suprajurensis, *Röm.*
—— gigantea, *Sow.* (P. striata, *Sow.*).
Turbo clathratus, *Röm.* (T. subclathratus, *D'Orb.*).
—— sulcatus, *Koch.*
—— hilseana, *Koch.*
Trochus scalaris, *Röm.*
Ostrea macroptera, *Sow.*
Exogyra sinuata, *Sow.* (O. aquila, *Brong.*).
—— Boussingaulti, *D'Orb.* (E. subplicata, *Röm.*).
Exogyra tuberculifera, *D. & K.* (E. spiralis, and reniformis, *Goldf.*).
—— undata, *Sow.*
—— haliotoidea.
Plicatula ornata, *Goldf.*
—— imbricata, *Koch & Dunker.*
Pecten cinctus, *Sow.* (very rare).
—— striato-punctatus, *Röm.*
Avicula Cornueliana, *D'Orb.* (A. macroptera, *Röm.*), very abundant.
Perna Mulleti, *Desh.* (very rare).
Lima plana, *Röm.*
—— subrigida, *Röm.*
—— longa, *Röm.* (L. elongata, *Röm.*).
—— stricta, *Röm.*
Modiola rugosa, *Röm.*
—— pulcherrima, *Röm,*
Arca exsculpta, *Koch.*
Nucula subtrigona, *Röm* (? N. subtriangula, *K. & D.*).
Venus parva, *Sow.* (V. subinflexa, *Röm.*).

* In this bed was found a single specimen of *Perna Mulleti*, Desh., a shell which has also occurred in considerable abundance in sandstones of the same age (Middle Neocomian) in the Teutoburger Wald and in Holland. M. Cornuel records it (Bull. Soc. Géol. Fr. 2me sér. t. viii.) from the Upper and Lower Neocomian of the Dept. of the Haute-Marne; in this country it has only occurred in the Upper Neocomian Atherfield Clay and the cement-beds of Speeton.

Waldheimia celtica, *Mor.* sp.
Terebratula oblonga, *Sow.* (T. biplicata, var. acuta, *Von Buch*).
—— faba, *Sow.*
—— tamarindus, *Sow.*
—— Puscheana, *Röm.*
—— sella, *Sow.*
Rhynchonella varians, *Schloth.* (?)
—— multiformis, *Röm.*
—— Renauxiana, *D'Orb.*
Crania irregularis, *Röm.* (Crania subquadratus, *K. & D.*).
Serpula Phillipsi, *Röm.*
—— antiquata, *Sow.*
Pollicipes Hausmanni, *Dunk. & Koch.*
Asterias (?) Dunkeri, *Röm.*
Cidaris variabilis, *Dunk. & Koch.*
Pentacrinus annulatus, *Röm.*
Synhelia Meyeri, *K. & D.* sp.
Sponges.

The railway from Kreiensen to Holzminden, which was constructed between 1861 and 1864, passes along the south-western foot of the Hils-chain, and in a series of cuttings yields a number of valuable sections, which have been fully described by Dr. Brauns *.

Underneath the "Flammenmergel," presenting the usual characters and containing Gault fossils, occurs the "Hilssandstein," a thick series of sands, usually soft and light-coloured, but occasionally greenish and containing an argillaceous matrix, at other times with veins and partings of a deep brown colour. In places, these sands are indurated into stone; and a valuable building-material is quarried from the upper part of the series. In the lower parts occur beds of ironstone, which are worked by open adits driven into the hill-side. This series of sands, which is over 300 feet in thickness, resembles in a most striking manner the Shanklin sands of the south of England and the Upper Neocomian sands of Lincolnshire. Unfortunately the Hilssandstein has yielded but very few fossils, only a few fragments of *Hamites*, and one Ammonite (*A. Milletianus*, D'Orb.)† having been recorded from it. M. von Strombeck is inclined to refer these beds to the Gault; but I cannot help thinking that they will be found to represent the upper part of our "Lower Greensand"—that is, the highest beds of the Upper Neocomian.

Underneath the Hilssandstein occur beds of light-coloured tenacious clay, 70 feet thick, containing *Belemnites Ewaldi*, Von Stromb., *Isocardia angulata*, Phil., a *Nucula*, and a small *Pleurotomaria*. These beds are probably on the same horizon as our Atherfield Clay and the "Cement-beds" of Speeton; that is, the base of the *Upper* Neocomian.

Beneath these we find beds of dark-coloured clay, 170 feet thick, interstratified in their lower portion with layers made up of grains of hydrated peroxide of iron. These strata, which rest on the Wealden, yield a *Middle*-Neocomian fauna, including:—

Belemnites lateralis, *Phil.*
Ammonites noricus, *Schloth.*
—— bidichotomus, *Leym.*?
Ancyloceras (Crioceras) Duvali, *Lév.*
Terebratula sella, *Sow.*
Waldheimia celtica, *Mor.*
Rhynchonella depressa, *D'Orb.*

5. *The Hartz.*—Along the northern foot of the Hartz range, between Harzburg and Goslar, there occur, as shown in the maps

* "Die Stratigraphie und Paläontographie des sudöstlichen Theiles der Hilsmulde" u. s. w., Palæontographica, xiii. p. 75 (Jan. 7, 1865).

† This fossil occurs, according to M. Cornuel, both in the Gault and in the Neocomian of France.

of Prof. Beyrich *, beds clearly referable by their fossils to the Neocomian. These beds dip at a very high angle (70°), and perhaps form an anticlinal; they consequently occupy only a very small area.

I found these beds to vary very greatly in character within short distances, sometimes consisting of dark-blue clays, in places containing beds of ironstone, sometimes passing into interstratified clays and limestones (greatly resembling those of Tealby), and sometimes consisting of unfossiliferous white, greenish, and brown, often conglomeratic, sands and sandstones. The clays and limestones here yield an abundant fauna, which enables us to refer the beds, without the slightest doubt, to the Middle Neocomian. The fossils which I collected from these beds in the vicinity of Ocker are as follows:—

Pecten cinctus, *Sow.* (very abundant).
Exogyra sinuata, *Sow.* (very abundant).
Belemnites jaculum, *Phil.* (very abundant).
—— lateralis, *Phil.* ?
Ostrea macroptera, *Sow.*
Pecten orbicularis, *Sow.*
Serpula antiquata, *Sow.*
—— filiformis, *Sow.*
Terebratula, sp.
Rhynchonella multiformis, *Röm.*
Sponges.

Northwards from Goslar, at the brickyard of Olhey, blue clays are dug, containing *Ammonites Deshayesi*, Leym., *Ammonites Martini*, D'Orb., *Crioceras*, sp., and other shells, which show clearly that these beds belong to the *Upper* Neocomian.

The "Subhercynischer Unter-Quader-Sandstein," like the Hilssandstein, which it resembles in general characters, contains but few fossils. These beds have been referred by M. von Strombeck to the Gault; it is not improbable, however, that they will prove to represent the highest member of the Neocomian.

6. *Brunswick.*—In this country the Neocomian series is more complete than in any other part of North-Western Germany; and it has been most admirably illustrated by the map and the various memoirs by M. von Strombeck †, who during many years has devoted himself with so much zeal and success to the study of the geology of this district.

The *Upper* Neocomian is represented by the following succession of beds.

(1) Whitish marly clay seen in the neighbourhood of Brunswick and at several other points—"Gargas-Mergel" ("zone of *Ammonites Nisus,*" Von Strombeck). The fossils of this bed are—

Belemnites Ewaldi, *Von Stromb.*
Ammonites Nisus, *D' Orb.*
—— Deshayesi, *Leym.*
—— Martini, *D' Orb.*
Toxoceras Royerianus, *D' Orb.*
Avicula aptiensis, *D' Orb.*
Rhynchonella lineolata, *Phil.*
Terebratula Martiniana, *D' Orb.*
—— Moutoniana, *D' Orb.*
—— hippopus, *D' Orb., non Röm.*
Pollicipes, sp.
Cidaris, sp.

* Beyrich, Zeitschr. d. deutschen geol. Gesellsch. i. p. 302, Karte iii. Karte 15; ix. p. 415; xi. p. 73, &c.

† Geognostiche Karte des Herzogthums Braunschweig, 1856. Beilage zu der geognostiche Karte des Herzogthums Braunschweig, 1857. "Ueber die Neocomien-Bildung," &c., Zeitschr. d. d. geol. Gesell. vol. i. p. 462. "Ueber die Echimiden des Hils-Konglomerat," &c. Neu. Jahrb. 1855, p. 641. "Bemerkungen über des Hils-Konglomerat und den Speeton-Clay bei Braunschweig," Neu. Jahrb. 1855, p. 159. "Ueber der Gault," &c. Zeitschr. d. d. geol. Gesell. 1861, p. 20, &c. &c.

(2) Dark-coloured clays with *Ammonites Martini*, *Am. Deshayesi*, *Crioceras*, &c. ("Zone of *Ammonites Martini*." Von Strombeck.)

(3) Dark-blue clays with septaria but with few or no fossils.

The *Middle* Neocomian appears to be represented in Brunswick by the following strata:—

(4) Dark-blue very tenacious clay full of fossils ("Speeton-Thon," "zone of *Belemnites brunswicensis*," of Von Strombeck)*. It contains the following:—

Belemnites brunswicensis, *Von Stromb.*
Ammonites Nisus, *D'Orb.*
Pecten cinctus, *Sow.*
Thracia Phillipsi, *Röm.*
Avicula Cornueliana, *D'Orb.* (A. macroptera, *Röm.*).
Panopæa plicata, *Sow.*
—— neocomiensis, *Leym.*
Pinna gracilis, *Phil.*
Terebratula Moutoniana, *D'Orb.*
Serpula Phillipsi, *Röm.*
Meyeria ornata, *Phil.* sp.

(5) Dark-blue clays abounding with *Ancyloceras* ("zone of *Crioceras Emmerici*" of Von Strombeck). This bed contains the following:—

Ancyloceras Emmerici, *Lév.*
—— semicinctus? *Röm.*
Belemnites brunswicensis, *Von Stromb.*
Serpula Phillipsi, *Röm.*
Lima longa, *Röm.*
Terebratula Moutoniana, *D'Orb.*
Rhynchonella antidichotoma, *D'Orb.*

(6) Unfossiliferous clays.
(7) Beds of clay full of *Exogyra sinuata*, Sow. ("zone of *Ostrea Couloni*, var. *aquila*" of Von Strombeck).
(8) Unfossiliferous clays.

The total thickness of these clays, representing the Upper and Middle Neocomian, is, in places, according to M. von Strombeck, upwards of 400 feet.

The *Lower* Neocomian is represented by beds of limestone and sandy marl, containing in places many nodules of iron-ore. The uppermost of these beds abound with specimens of the highly characteristic *Toxaster complanatus*, Ag. The whole series, which never exceeds 50 feet in thickness, is crowded with fossils, among the most characteristic of which appear to be the Echinoderms, no fewer than 10 species being cited by M. von Strombeck as common to and equally characteristic of these beds and the "*Marnes d'Hauterive*" &c. (Lower Neocomian) of the Jura.

The following list will show the nature of the fauna of these beds, which are well seen at Gross Vahlberg, Berklingen, Schandelahe, Schoppenstedt, &c.

Belemnites lateralis, *Phil.*
Ammonites Astierianus, *D'Orb.*
—— bidichotomus, *Leym.*
—— radiatus, *Brug.* (A. asper, *Merian*).
—— noricus, *Schloth.*
Trochus bicinctus, *Röm.* (T. tricinctus, *Röm.*).
Pleurotomaria discoidea, *Röm.*
Ostrea macroptera, *Sow.*
—— subcomplicata, *Röm.*
—— Leunisi, *Röm.*
—— micrantha, *Röm.*
Exogyra Boussingaulti, *D'Orb.* (E. subplicata, *Röm.*).
—— Couloni, *Defr.* (very abundant).

* M. von Strombeck, who first noticed these beds, was so struck with the number of fossils agreeing with those figured in Phillips's Geology of Yorkshire (omitting the supposed Gault forms) that he named this bed the "Speeton-Thon."

Exogyra spiralis, *Röm.*, var.
—— undata, *Sow.*
Pecten cinctus, *Sow.*
—— lineo-costatus, *Röm.*
—— atavus, *Röm.*
Avicula Cornuelianus *D'Orb.* (A. macroptera, *Röm.*).
Lima semicostata, *Röm.*
Serpula Phillipsi, *Röm.*
—— unilineata, *Röm.*
—— gordialis, *Schloth.*
—— angulosa, *Röm.*
—— antiquata, *Sow.*
—— quinqueangulata, *Röm.*
Terebratula sella, *Sow.*
—— Moutoniana, *D'Orb.*
—— faba, *Sow.*
—— tamarindus, *Sow.*
—— hippopus, *Röm.* nec *D'Orb.*
—— oblonga, *Sow.*
Terebratula Puscheana, *Röm.*
Rhynchonella depressa, *D'Orb.*
Thecidea tetragona, *Röm.*
Crania irregularis, *Röm.* (C. hexagona, *Röm.*).
Toxaster complanatus (*Gmel.*), *Ag.*
Holaster Hardyi, *Dub.*
Dysaster ovulum, *Ag.*
Pygurus Montmolini, *Ag.*
Nucleolites Olfersii, *Ag.*
—— Gresslyi, *Ag.*
Pyrina pygæa, *Desor.*
Holectypus macropygus, *Desor.*
Diadema rotulare, *Ag.*
—— Bourgueti, *Ag.*
Montlivaltia explanata, *Röm.*, sp.
Cladophyllia nana, *Röm.*, sp.
Holocœnia micrantha, *Röm.* sp.
Thamnastræa Leunisi, *Röm.* sp.
Very numerous species of sponges*.

M. von Strombeck considers that these Lower Neocomian beds of Brunswick are divisible into two zones (Zone of *Toxaster complanatus*, and Zone of *Ammonites bidichotomus*), the uppermost of which he parallels with the *Marnes d'Hauterive* of Switzerland, and the lower he doubtfully refers to M. Desor's "*Valanginien*"†.

Throughout the whole of North-western Germany the Neocomian strata lie underneath a great mass of clays, including the Flammenmergel and some other deposits, some of which locally pass into sands, the whole being over 300 feet thick.‡ These beds (in their upper portion, at least) are clearly seen by their fossils to represent our Gault; their lower portion may possibly represent some of the beds intermediate between the Gault and Neocomian, generally absent in this country. These clays are in turn overlain by the various beds of the chalk, which present many points of analogy with the equivalent beds in the north of England; this is especially seen in the presence of red beds in the lower part of the series, though these are of much greater thickness and importance in Germany than in this country.

The strata next below the Neocomian of Westphalia, Hanover, and the Hartz consist of that great mass of fluviatile beds, in places reaching to a thickness of 2650 feet (?), and containing many

* *Vide* Fr. Ad. Römer, "Die Spongitarien des norddeutschen Kreidegebirges," Palæontographica, vol. xiii. (1864).

† The presence in considerable abundance of *Pecten cinctus*, Sow., in the Lower Neocomian of Brunswick is a very interesting circumstance. This shell appears generally to characterize well, by its constant presence and great abundance, the Middle Neocomian in Northern Europe, and to take the place of the *Chama ammonia* of the same beds in Southern Europe. In Brunswick and the south of France (in which last district, however, it appears to be rare) this shell occurs in the *Lower* Neocomian.

‡ The *red* sandstones, containing *Ammonites auritus*, Sow., of Neuenheerse, in the Teutoburger Wald, perhaps form a link between the Gault clays, with which they are associated, and the Hunstanton limestone, which, as we have seen, is last found in Heligoland.

workable beds of coal, which are referred by German geologists to the Wealden. These beds have been very fully described, and their numerous points of resemblance to the English Wealden shown, by many German geologists, especially by Koch, Dunker, and Von Meyer*, and more recently by Credner†. In Brunswick this formation does not occur; and the presence there of Lower Neocomian beds is therefore a very significant fact.

With regard to the stratigraphical relations of the Neocomian beds in North Germany it is not easy to arrive at any very definite conclusion, the country not having been mapped in sufficient detail. The manner, however, in which the Cretaceous beds are found overlapping and resting on different members of the Neocomian appears to indicate the existence, as in England, of an unconformity between these two series. Similarly the Hilsconglomerat (Lower Neocomian) of Brunswick appears to lie indifferently on any of the older rocks, and is therefore probably unconformable to the Jurassic series.

VI. Conclusion.

We have thus seen that the Neocomian beds of Yorkshire and Lincolnshire are the most westerly development of a great mass of strata, of the same age, stretching over a wide area in Northern Europe. It is true that the beds of this age are neither so well exposed nor do they attain so great a thickness as in the south of Europe; but they nevertheless present us with a remarkably similar succession of faunas. At the eastern and western extremities of the area, in Brunswick and in Yorkshire respectively, the marine series is complete, and we have the three divisions of the Neocomian formation all developed; but in the intermediate districts of Westphalia, Hanover, and the Hartz, the marine beds represent only the Upper and Middle Neocomian, and these rest upon the freshwater strata of the North-German Wealden.

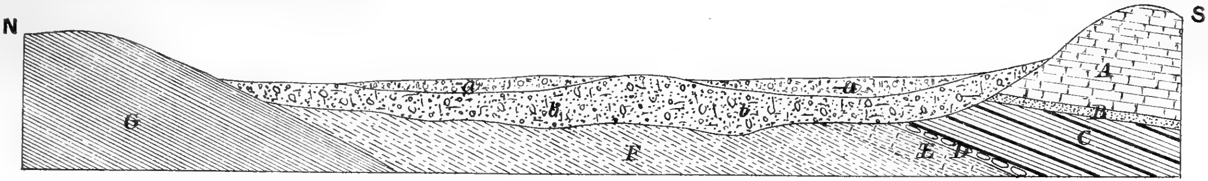
The section at Speeton Cliff derives additional interest from the fact that it is by far the most complete exposure of the Neocomian beds over the whole of the great North-European area. The sections elsewhere are more or less isolated and fragmentary; but at Speeton we find the key by means of which they may be identified and correlated.

We have seen that, over the North-European area, a remarkable uniformity of character is maintained among the Neocomian strata (and the same is, to a certain extent, true also of the Cretaceous and Jurassic), indicating that this district forms a natural province, not improbably representing an ancient sea-basin. The ridge of Palæozoic land traced by Mr. Godwin-Austen in his celebrated memoir "On the Possible Extension of the Coal-Measures beneath the South-Eastern part of England" ‡ may not improbably have formed

* "Monographie der Norddeutschen Wealdenbildung," &c. (1846), Palæontographica, &c.

† Ueber die Gliederung der oberen Juraformation und der Wealden-Bildung im nordwestlichen Deutschland (Prague, 1863).

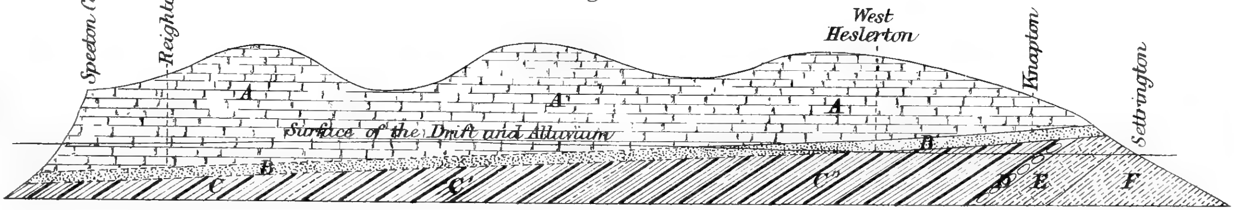
‡ Quart. Journ. Geol. Soc. vol. xii. 1856, p. 38. See also Mr. S. V. Wood, jun.,



b. Drift

IDEAL SECTION THE NORTHERN ESCARPMENT OF THE YORKSHIRE WOLDS.

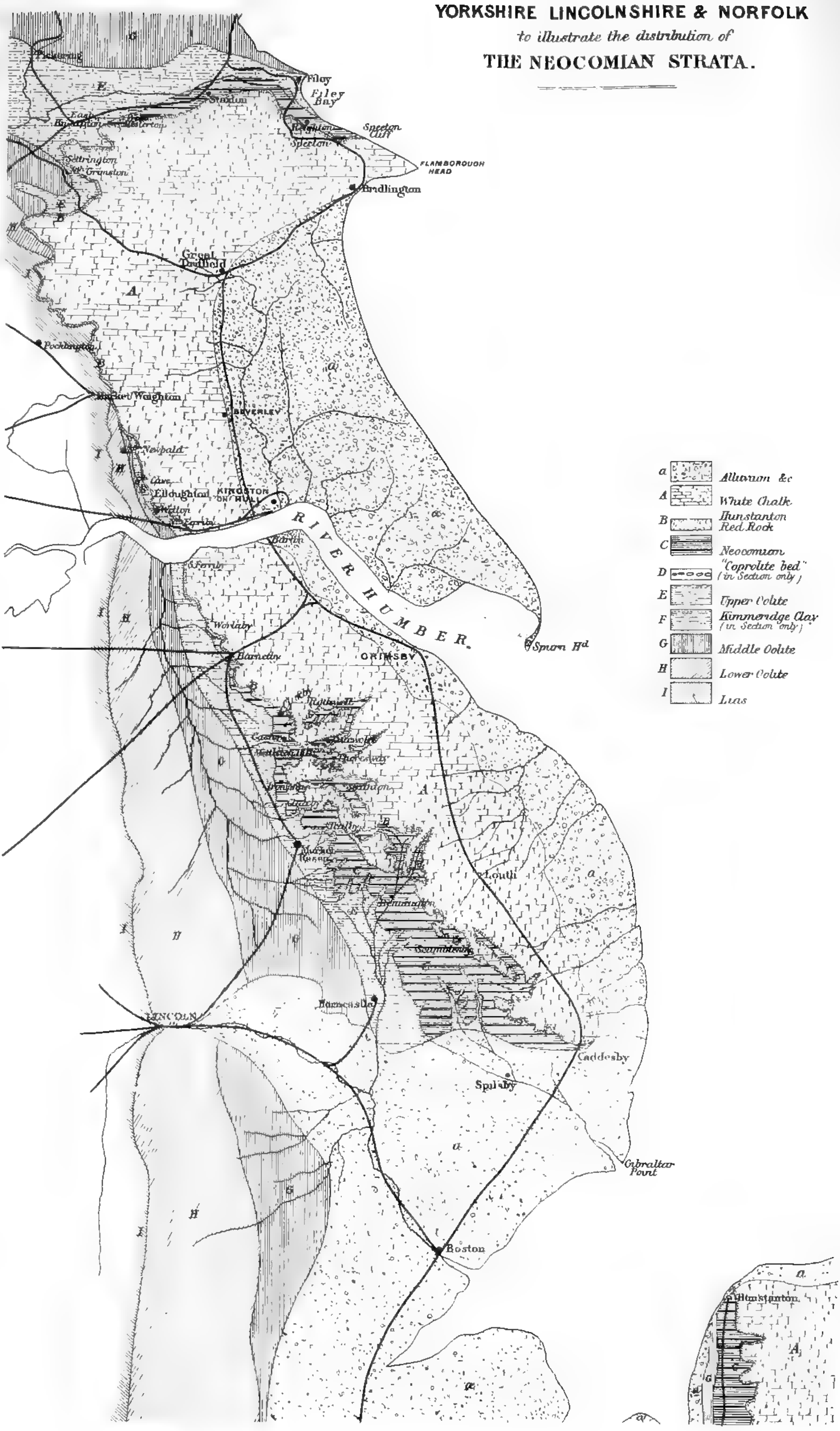
Fig. 2.



F. Daugerfield lith: 22, Bedford St. Covent Garden.

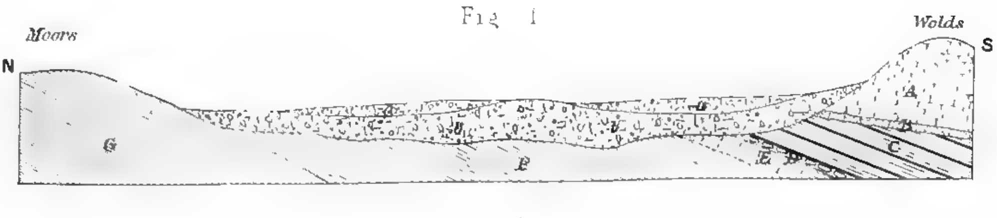
Fig 3

SKETCH MAP
of parts of
YORKSHIRE LINCOLNSHIRE & NORFOLK
to illustrate the distribution of
THE NEOCOMIAN STRATA.



IDEAL SECTION ACROSS THE VALE OF PICKERING FROM N to S

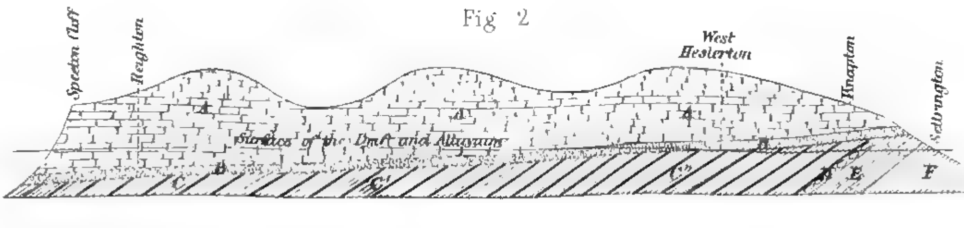
Fig 1



b Drift

IDEAL SECTION THE NORTHERN ESCARPMENT OF THE YORKSHIRE WOLDS.

Fig 2



I Dangerfield lith 22 Bedford St Covent Garden

the barrier between this Anglo-Germanic and the Anglo-Parisian basin. The points of resemblance and difference, and the mutual relations of the Neocomian strata in the Anglo-Germanic, the Anglo-Parisian, the Jura, and the Mediterranean basins, I hope (should I be able to continue my study of these beds) to treat of in a future communication.

The succession of beds which I have described at Speeton, while its remarkable parallelism with the equivalent beds in Southern Europe has been generally acknowledged by Continental geologists*, has been appealed to by the advocates of several different schemes of classification as supporting their respective views†. Into these questions of classification, however, I refrain, for the present, from entering.

EXPLANATION OF PLATE XXIII.

Fig. 1. Ideal section across the Vale of Pickering.
a. Alluvium. *b*. Boulder-clay and other "drift" deposits. A. White Chalk. B. Hunstanton Red Rock, lying unconformably on C. Speeton Clay proper (Neocomian). D. "Coprolite Bed" (marking unconformity). E. Portlandian Clays. F. Kimmeridge Clays. G. Coralline Oolite.

Fig. 2. Ideal section along the northern escarpment of the Yorkshire Wolds.
A. White Chalk. B. Hunstanton Red Rock. C, C′, C″. Upper, Middle, and Lower Neocomian. D. Coprolite Bed. E. Portlandian. F. Kimmeridge.

Fig. 3. Sketch Map of parts of Yorkshire, Lincolnshire, and Norfolk, to illustrate the distribution of the Neocomian strata.
a. Alluvium &c. A. White Chalk. B. Hunstanton Red Rock. C. Neocomian. E. Upper Oolite. G. Middle Oolite. F. Lower Oolite. I. Lias.

Discussion.

Mr. Etheridge stated that he had examined sections in Brunswick and Hanover, at Hildesheim, and other places, and confirmed Mr. Judd's results. He remarked upon the occurrence of *Pecten cinctus* in the Middle Neocomian in England and in the Lower Neocomian in Germany.

Sir Charles Lyell noticed the occurrence of anticlinals and contortions in the Brunswick district, and remarked upon the comprehensiveness now ascribed to the "Speeton Clay," and on the correspondence of the phenomena observed in Yorkshire with those presented in the south of England, in passing from Folkestone to the Isle of Wight. He also mentioned the occurrence of *Ammonites Deshayesii* in the Hastings sand at Punfield, as indicating the marine and cretaceous nature of that deposit.

The President inquired as to the evidence of the representation of the Lower Neocomian by Wealden deposits in Germany.

Mr. Judd remarked that the Punfield marine band is absolutely en-

"On the events which produced and terminated the Purbeck and Wealden deposits of England and France," Phil. Mag. 4th ser. vol. xxv. (1863) p. 268.

* Bull. Soc. Géol. Fr. 2me sér. tom. xxvi. pp. 211–216 (1869).

† *Vide* "Notes on Continental Geology, by T. Davidson," Geol. Mag. 1869.

closed in the Wealden, and that its fossils have an Upper Neocomian character, with a clear affinity to a Spanish series. He regarded the Wealden of North Germany as not strictly contemporaneous with that of England, and stated that the "Hilsconglomerat" in Brunswick was a shore-deposit, but that its relation to the Wealden could not be observed.

---

2. *On* Deep-mining *with* Relation *to the* Physical Structure *and* Mineral-bearing Strata *of the* South-west *of* Ireland. By Samuel Hyde, Esq.

(Communicated by R. Etheridge, Esq., F.G.S.)

[Abstract.]

The author described the general structure of the country in the south-west extremity of Ireland, which he stated to consist of a series of rocks analogous to the "Killas" of Cornwall, and belonging to the upper part of the Lower, or the lower part of the Upper Devonian series. He combated the opinion which had been expressed by the late Professor Jukes, that copper-ores would not be found in the district in sufficient quantities to make mining there a remunerative process. In support of his thesis, he cited the Bearhaven mines, established about fifty years ago, the Allitries and Ballycummisk mines, and the Coosheen mine. He stated that in the Ballycummisk mines a depth of 200 fathoms has been reached, and that some of the shafts at Bearhaven are much deeper. These deep workings were said to yield large returns of ore. In opposition to the opinions stated by the late Professor Jukes, the author maintained that the copper lodes were of the same nature as those of Cornwall, and he described them as running in a similar direction, namely, 10°–25° N. of E. From the similarity in the geological constitution of the country, and in the direction of its mineral veins, the author was inclined to infer a former continuity between the south-western promontories of the islands of Great Britain and Ireland.

Discussion.

Mr. David Forbes protested against the notion that the Devonian strata themselves were metalliferous, the veins being of much later date—in the present case Postcarboniferous. He maintained that there was no valid reason for supposing that the veins became unproductive with increased depth, and opposed the notion that they had been filled in by segregation from the surrounding rock. He alluded to the use of spectroscopic analysis in such inquiries, and remarked that as no trace of copper is to be found in the rock even immediately adjacent to veins, we should have to admit, on the hypothesis of segregation, that the rock must originally have contained precisely the amount of metal segregated in the veins.

Mr. Etheridge agreed with Mr. Forbes as to the date of the filling in of the veins. He also maintained the justice of correlating the rocks with those of the Cornish area.

Mr. Hyde briefly replied.

MARCH 9, 1870.

John Alleyne Bosworth, Esq., of Humberston, Leicestershire; Robert Erskine Brown, Esq., of Wass, Oswaldkirk, Yorkshire; Major E. H. Sladen, Madras Staff Corps, Church Road, Upper Norwood; and Henry King Spark, Esq., Greenbank, Darlington, were elected Fellows of the Society.

The following communications were read:—

1. *On the* STRUCTURE *of a* FERN-STEM *from the* LOWER EOCENE *of* HERNE BAY, *and on its* ALLIES, RECENT *and* FOSSIL. By WM. CARRUTHERS, Esq., F.L.S., F.G.S., British Museum.

[PLATES XXIV. & XXV.]

THE Royal Fern (*Osmunda regalis*, Linn.) is the noblest and most striking of our British ferns. The tuft of fronds under favourable circumstances attains a height of nearly 12 feet, and the erect stem is sometimes more than 2 feet long. The stem is perennial, growing in tufts, formed by the repeated dichotomous division of the terminal bud; the whole is matted together by a large mass of adventitious wiry roots. The different stems are stout and firm, and densely covered with the permanent bases of the petioles. It is found in wet, springy, or boggy places all over Britain, and is indeed generally distributed over the northern temperate zone. With one other genus, *Todea*, it forms a small but well-marked natural group of ferns, the *Osmundaceæ*.

I have determined the existence of *Osmunda regalis* in the Norwich Forest-bed from large specimens collected by the Rev. J. Gunn. It is common in the newer submerged forests, having maintained its ground through all the changes that have taken place.

Three closely allied forms have been found in the later Tertiary strata; the oldest was obtained from a bed at the base of the Miocene period. I have now to add a fourth from the Lower Eocene at Herne Bay.

This species is based upon a portion of a stem in the collection of George Dowker, Esq., F.G.S. It is somewhat unequally weathered and water-worn, one of its sides being rubbed nearer to the centre than the other. The whole of the tissues are replaced by silica, and this in so perfect a manner that the most delicate structures are exquisitely preserved.

Externally the specimen exhibits the roundish petioles, irregularly broken, and marked with a single crescentic vascular bundle. Numerous adventitious roots separate the petioles from each other.

In section the stem is found to have the following structure. Near one side, from the unequal wearing of the specimen, is the slender true stem: this is composed of a white parenchymatous medulla, a narrow scalariform cylinder, and a parenchymatous cortical layer. The parenchyma of the medulla consists of roundish thin-walled cells. The slender vascular cylinder is repeatedly interrupted by the long slender meshes, from the margin of which proceed the vascular bundles that supplied the fronds. These meshes

or slits passed upwards and outwards through the cylinder; and in transverse section they are seen either completely breaking up by a thin film of cellular tissue the continuity of the cylinder, or only penetrating it for a short distance. Such partial penetrations sometimes proceed from the inside and sometimes from the outside of the cylinder, depending upon the part of the particular mesh which has been cut. When the mesh is cut near its origin, the cylinder is complete on its outer margin; while when it is cut through the upper portion, the cylinder is complete on its inner margin. Dr. Ogilvie, in a valuable paper on the vascular and woody tissues of ferns (Annals and Magazine of Nat. History, 3rd ser. vol. vi. (1860) p. 320, pl. v.), has somewhat misinterpreted this vascular cylinder in *Osmunda regalis*. He says the cylinder is made up of about eight fasciculi, having the same crescentic section as the vascular bundle in the petiole, and having their concavities all turned inwards. This is figured and described in plate v. fig 1. His error arises from his entertaining the notion that the vascular cylinder is composed of the fasciculi of the petioles, which, when they descend into the stem, branch out and anastomose with those derived from former petioles. This cylinder, however, is formed independently of the food-producing leaves, or at all events in advance of them; and the meshes are really the openings through which the fasciculi pass to the leaves. These meshes do not in any way represent the reticulations caused by the medullary rays in the wood of Dicotyledons. They are homologous with the meshes produced by the tissues which pass through the wood into the foliar or ramal appendages.

The vascular cylinder of the stem is surrounded by a thin layer of pale parenchyma similar to that composing the axis. Dr. Ogilvie calls this a cambium layer; but he overlooks the fact that the vascular bundles in ferns are definite and simultaneous, and that a cambium layer does not exist in this position.

The vascular bundles of the petioles spring from the meshes in the vascular cylinder. At their origin they have the crescentic form which characterizes them throughout their whole course in the petiole and rachis, as well as all the branches in the secondary rachides. Each petiole is composed of its vascular bundle, having the concavity of the crescent looking towards the axis of the stem. This is imbedded in a pale parenchyma, composed of slightly oblong cells; and the whole is surrounded by a cortical layer of smaller but more elongated cells, deeply coloured by the deposit in their interior of the brown-coloured substance so extensively distributed in ferns, and which is said, from its abundance in them, to give a peculiar rusty tint to the vegetation of those districts in which (as in some parts of New Zealand) ferns form a prevailing feature. Near the base the petiole is furnished with a wing, which is composed of white cellular tissue enclosed in a thin epidermis. In addition to the colouring-matter in the cortical layer of the petiole, a few small bundles of elongated cells occur irregularly scattered through the central parenchyma, both in the hollow concavity of the vascular bundle and on

its convex surface. The cells adjacent to the inner concave surface of the vascular bundle have a deposit of colouring-matter in them; but this disappears towards the base of the petiole. I am able to confirm the correctness of Dr. Ogilvie's description of this dark band in the petioles of *Osmunda regalis*; but it is probably not always present, as Prof. Church was not able to detect it in the specimens he examined (Linn. Soc. Journal, Botany, vol. vii. 1864, p. 88). Bundles of coloured cells occur, also, irregularly scattered through the parenchyma of the wings.

The axis gives off in the older portions numerous adventitious roots. These proceed, as in tree ferns, from the interpetiolar spaces, and are not developed from the base of each petiole as figured and described by Duval Jouve in the living plant (Billot's Annotations à la Flore de France, 1855, p. 51, pl. 1. fig. 5 A). In the fossil I have a preparation showing their independent origin; and in the living Royal Fern I have dissected them out, tracing them into the vascular cylinder. They have a different structure from that of the petioles, being more or less circular in transverse section, and composed of a small central vascular bundle imbedded in a very little pale parenchyma, and both surrounded by a cylinder of very dark brown elongated cellular tissue. On issuing from the axis the root pushes through the cellular tissues of the petioles, until it is able to pass upwards between two. It then repeatedly branches; and when it escapes beyond the bases of the petioles the branches become long and wiry, and form a dense covering around the recent stems. This has disappeared from the fossil, because of the rubbing to which it has been subjected; but the branching roots are obvious among the petioles in the least-worn surface.

The singularly perfect preservation of the tissues of this fossil is very remarkable. Not only are all the cells and vessels intact, but even the starch-granules, which abound in the parenchyma of ferns, still fill the cells in which they were originally formed; or rather, I should say, the silica by which they are replaced, and which assumes their form, is there. In the form of the granules, and in the method in which they are packed in the cells, the fossil agrees exactly with the recent species. Many of the cells contain the mycelium threads of a parasitic fungus, which are inarticulate, and probably belong to the genus *Peronospora*, one species of which is too familiar from the injury it has brought on the potato crops. The dead stem of the fossil must have been at once attacked by this parasite; it could never have been desiccated, as the most delicate tissues are perfectly preserved. Buried in the moist clay, the silica must have speedily replaced the organic tissues before the most delicate cells, the mycelium threads, or even the starch-granules were disorganized.

The position of the fossil cannot be doubted. It certainly belongs to *Osmundaceæ*, and most probably to the genus *Osmunda*. It would be referred without hesitation to this genus by some workers in fossil botany; but it seems to me most desirable not to refer positively a fossil to a recent genus which has been established upon characters that are not present, and consequently cannot be determined, in the

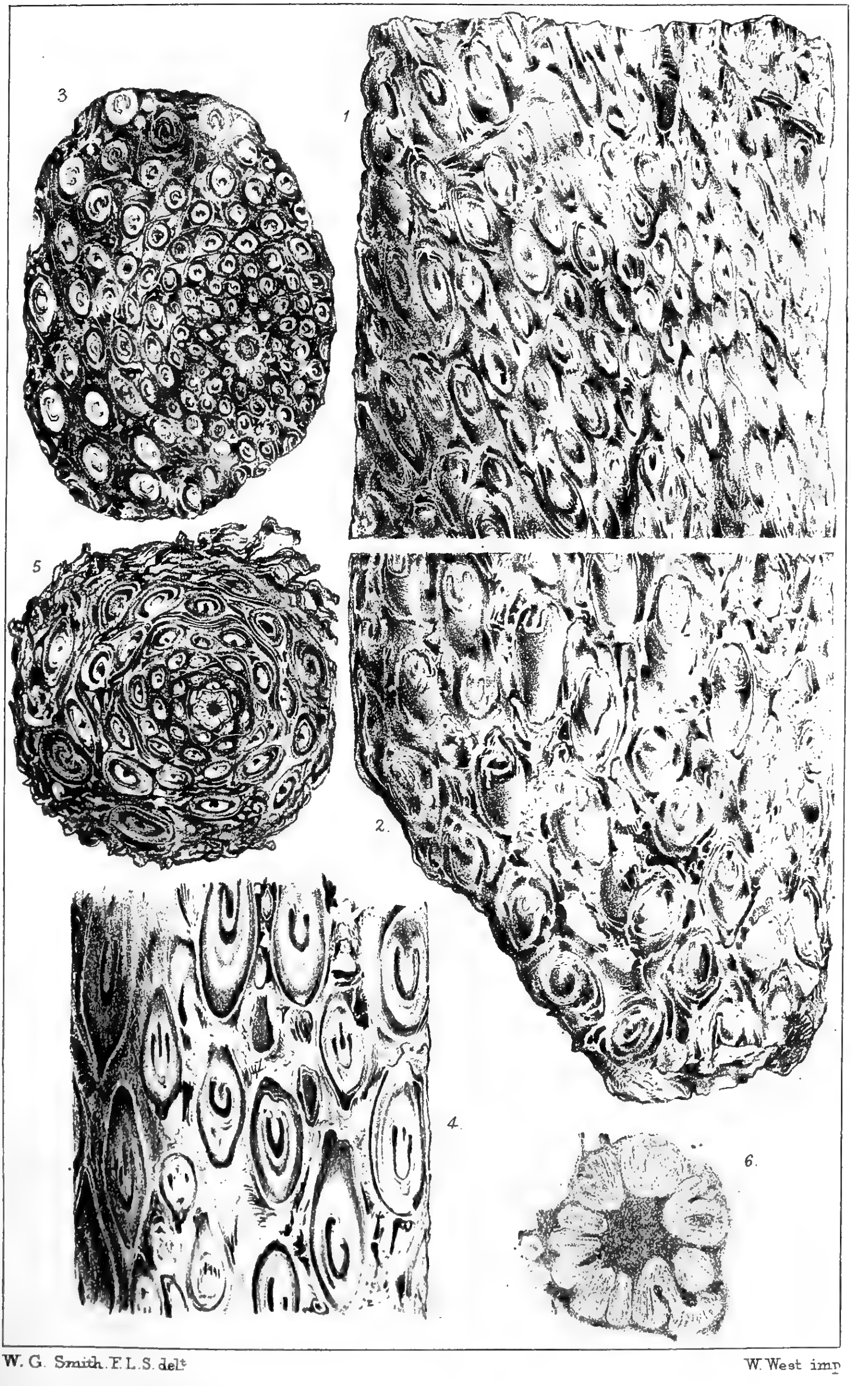
fossil. No botanist dealing with living plants would venture on such materials to decide on their place, far less to describe them as forming a new species. It is very different with fossils belonging to the animal kingdom, where the portion of the organism preserved is generally that which is employed to a greater or less extent in the classification of recent forms. I must therefore adhere to the system of nomenclature I have hitherto followed, notwithstanding that it has been censured by so distinguished a botanist as Prof. Heer (Flora Foss. Arct. p. 84), and consider this a species of *Osmundites*. It is no answer to this method to say that species of plants now living found in quaternary deposits, being so far fossil, ought to receive another name; for if the materials are sufficient to determine with certainty the specific identity of the two plants, of course, on the principle I adopt, the same name must be applied to both. It still seems to me of great importance to be able to distinguish the extinct from the existing species by the name, inasmuch as this distinction conveys also to the student, to some extent, the value of the evidence on which the species has been established.

The fossil has been a larger plant than our recent *Osmunda regalis*, or than a similar stem found in a mass of "Süsswasserquarz" near Schemnitz, figured by Pettko under the name *Asterochlæna schemniciensis* in Haidinger's Abhandl. vol. iii. (1850) p. 163, pl. xx., but afterwards referred by Unger to *Osmundites* (Denkschr. d. K. K. Akad. d. Wiss. vol. vi. (1853). I propose to associate with it the name of George Dowker, Esq., F.G.S., from whom I received the specimen, and to name it *Osmundites Dowkeri*. It was found on the shore at Herne Bay, and could have been obtained only from the Lower Eocene beds there—perhaps from the beds below the London Clay.

A group of fern stems are found in the later Palæozoic and in the earlier Mesozoic strata which are nearly allied to those of *Osmunda*. They have been, unnecessarily, divided into several genera; but as they all agree in having a slender caudex covered by the long ascending and permanent bases of the petioles, and numerous aërial roots, it seems better to unite them under Corda's genus *Chelepteris*. The materials are not sufficient to determine with any thing like precision the position of this group of stems; but in the characters I have just given they agree with the recent *Osmundaceæ*, as well as in having the vascular bundle of their petioles simple. There is at least a fair presumption that this is their position; yet it must be remembered that these characters are not peculiar to this recent tribe, but that they are found also in ferns widely separated from them in a natural classification, as, for instance, in *Dicksonia antarctica*. The genus *Chelepteris*, extended as I propose, would include the following species:—

From the Permian of Russia (Grès cuivreux of Orenbourg):—

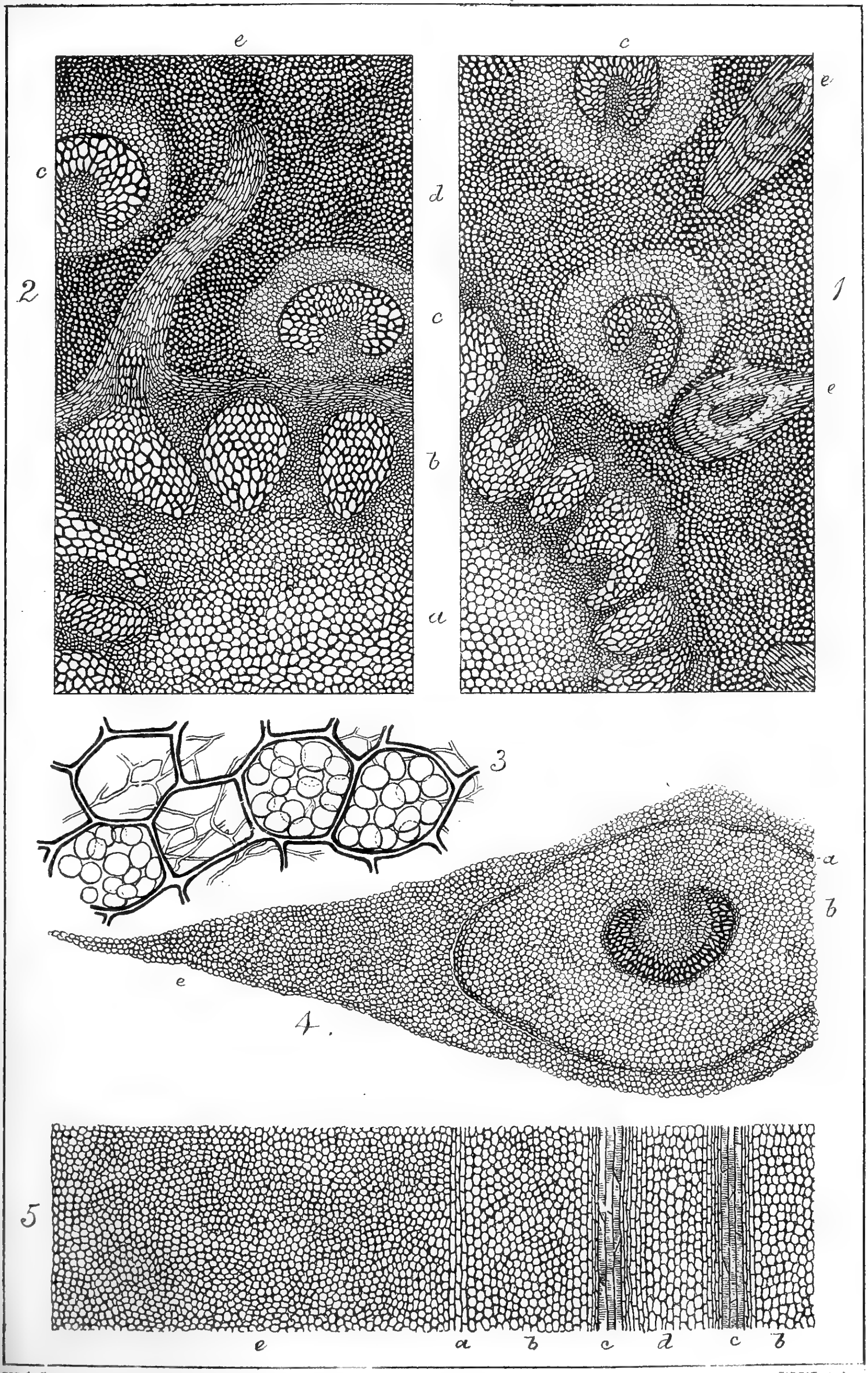
Thamnopteris Schlechtendalii, Brongn. Tabl. Genr. Foss. p. 36.
Bathypteris rhomboidea, Eichw. Leth. Ross. vol. i. p. 96.
Anomorrhœa Fischeri, Eichw. Leth. Ross. vol. i. p. 102.
Chelepteris gracilis, Eichw. Leth. Ross. vol. i. p. 98.



W. G. Smith. F.L.S. del^t

W. West imp

OSMUNDITES AND OSMUNDA.



W. G. Smith F. L. S. delt

W. West imp.

OSMUNDITES AND OSMUNDA

From the Lower Trias (Grès bigarré) of France, the following:—

Chelepteris vogesiaca, Schimp. Traité Pal. Vég. vol. i. p. 702.

Ch. Voltzii, Schimp. Tr. Pal. Vég. vol. i. p. 703.

Ch. micropeltis, Schimp. Tr. Pal. Vég. vol. i. p. 703.

Bathypteris Lesangeana, Schimp. & Moug. Monogr. Pl. Foss. des Vosges, p. 67.

And from the Keuper, near Würzburg:—

Chelepteris macropeltis, Schenk, in Von Meyer's Palæontogr. vol. xi. p. 304.

Bathypteris strongylopeltis, Schenk, in Verh. Phys. Med. Gesellsch. Würzb. vol. viii. p. 212.

EXPLANATION OF PLATES XXIV. & XXV.

Plate XXIV.

Figs. 1–3. *Osmundites Dowkeri*, Carr.

Figs. 1 & 2. Drawings of the outer surfaces of the specimen. Fig. 1 is the surface which has been most rubbed, and exhibits the bases of the petioles near their origin. Fig. 2 represents the less-worn surface, with larger petioles and adventitious roots. The lunate vascular bundle is shown at the ends of some of the petioles. Fig. 3 is a transverse section, showing the position of the axis and of the petioles and roots.

Figs. 4–6. *Osmunda regalis*, Linn.

Fig. 4. Outer surface of the caudex after the adventitious roots have been cut away. Fig. 5. Transverse section, showing the axis, petioles, and roots.

Fig. 6. Transverse section of the axis, showing the meshes in the vascular cylinder. All the figures are of the natural size.

Plate XXV.

Figs. 1, 3, & 4. *Osmundites Dowkeri*, Carr.

Fig. 1. Section of a portion of the centre of the stem, showing:—*a*, the central cellular tissue; *b*, the vascular cylinder with the meshes through which have passed the vascular bundles to the leaves; *c*, the tissues of two petioles or leaf-stalks; *d*, the dark-coloured parenchyma surrounding the axis; *e*, two adventitious roots. Fig. 3. A few cells, showing the starch granules, and the mycelium of the fungus. Fig. 4. Transverse section of a petiole, showing:—*a*, the boundary of the petiole; *b*, the parenchyma surrounding the vascular axis; and, *e*, the parenchyma of the wing of the petiole.

Figs. 2 & 5. *Osmunda regalis*, Linn.

Fig. 2. Transverse section of part of the axis, showing:—*a*, the central cellular tissue; *b*, the vascular cylinder; *c*, two petioles; *d*, the parenchyma surrounding the axis; *e*, a root springing from the vascular cylinder. Fig. 5. Longitudinal section of a petiole, showing:—*a*, the boundary of the petiole; *b*, the parenchyma; *c*, the scalariform tissue; *d*, the parenchyma separating the two extremities of the vascular bundle; *e*, the parenchyma of the wing of the petiole.

Discussion.

Mr. W. W. Smyth, in calling on those present for remarks on the paper, commented on the very remarkable manner in which the minutest details of the original plant had become silicified.

Mr. Etheridge mentioned the discovery of fossil fern-stems of somewhat similar character at Bromsgrove.

Prof. Ramsay suggested the possibility of the fossil having been derived from a bed even higher than the Thanet Sands. He thought the rarity of such delicate structures being perfectly preserved by

silicification not so great as might at first sight appear; for in Antigua and elsewhere vegetable forms had been converted into flint as completely and distinctly.

Mr. Woodward cited the hot springs in the Island of St. Michael as converting portions of vegetables still growing into flint. He had heard of the ends of piles being converted into flint in the course of thirty years, but had not yet seen them.

Mr. Jenkins inquired whether the Osmundaceæ from different formations offered any evidence of the climate under which they lived. He thought that where vegetable structures were perfectly preserved in flint, the process of silicification had gone on but slowly; but this fell more within the province of the chemist than the geologist.

Mr. Hulke suggested the possibility of the fern having contained a certain amount of silica while still living.

Prof. Morris referred the fossil to the Thanet Sands. He thought that the silica in fossilized coniferous and endogenous wood varied in character, and this might throw some light on the process of conversion. He considered that objects containing phosphate of lime, and those containing carbonate of lime, were subject to different processes of silicification.

Mr. Whitaker was strongly of opinion that the fossil had been derived from quite the upper part of the Thanet Sands.

Prof. Duncan called attention to the process of silicifiation as exhibited by the Antiguan corals, in which one highly insoluble mineral had been replaced by another almost as insoluble.

Mr. Carruthers, in reply, did not think that any thing could be predicated as to climate from extinct species; if this were attempted, a similar error to that with regard to the climate under which the fossil Elephants were supposed to have lived, might be repeated. Existing Osmundaceæ contained no silica in their structure. The peculiarity of the fossil under consideration was the preservation of the contents of the cells, even to the starch, which is so readily decomposed. The difficulty of accounting for the replacement of soft vegetable matter by hard mineral silica, seemed to him great.

---

2. *The* Oolites *of* Northamptonshire. By Samuel Sharp, Esq., F.S.A., F.G.S.

Introduction.

It is not without misgiving that I venture to offer to the notice of the Geological Society the following Memoir—justified in its production only by the fact that, during a residence of some years in Northamptonshire, I have been enabled, in the intervals of much other occupation, to acquire some familiarity with the geology of my own neighbourhood, and to make a collection of local fossils, which, in deference to "the inexorable logic of facts," I cannot but anticipate will prove of greater importance, as illustrative of the geology of the district, than any paper of which I may be the author.

It is fortunate for me that, as compared with some other districts, little has been written upon that of which I treat.

The earliest geological notice of the locality is, I believe, to be found in Conybeare and Phillips, 1822; but it must not be forgotten that Morton, in his quaint and, for his time, learned, 'Natural History of Northamptonshire,' published as early as 1712, described and figured, generally with accuracy, numerous fossils now as then obtainable from the geological formations of the county, including a *Trigonia* of a species not yet recorded as occurring in equivalent beds in other districts, and which Dr. Lycett has done me the honour of distinguishing by the name of *T. Sharpiana*.

A "Notice of the Geology of the Neighbourhood of Stamford and Peterborough," by the late Capt. Ibbetson, F.G.S., and Mr. (now Professor) Morris, F.G.S., was published in the 'Transactions' of the British Association for 1847.

The Rev. P. B. Brodie, F.G.S., in 1850, published, in the 'Transactions' of the 'Cotswold Naturalists' Club,' "A Sketch of the Geology of the Neighbourhood of Grantham, Lincolnshire, and a Comparison of the Stonesfield Slate at Collyweston, in Northamptonshire, with that in the Cotswold Hills."

An important paper "On some Sections in the Oolitic District of Lincolnshire" (touching also upon some points in the geology of Northamptonshire), by Professor Morris, F.G.S., was published in the Journal of the Geological Society for November 1853.

In his 'Handbook of the Cotswold Hills,' 1857, Dr. Lycett makes a passing allusion to the ironstones of Wellingborough.

In 1860 & 1861 appeared the Memoirs accompanying the Maps of the Geological Survey of the Southern Division of the County (sheet 53, quarters N.E. and S.E.), written respectively by Mr. Aveline and Messrs. Aveline and Trench.

Papers by Mr. Maw, F.G.S. (read April 1868, and published in the Journal), and by Mr. Judd, F.G.S. (read March 1869), treated of the mineralogical characteristics of the Northampton Sand; and the latter embodied considerations tending to show that the materials of these beds had been deposited under estuarine conditions.

Lastly, in the 'Geological Magazine' for March, 1869, is an interesting article by Professor Morris, F.G.S., entitled "Geological Notes on Parts of Northampton- and Lincolnshires."

Since the publication of the majority of these dissertations, many additional sections have been exposed, large collections of the palæontological contents of the several beds have been accumulated, and the geological sequence of those beds has been systematically traced over a considerable area.

The knowledge thus made accessible necessitates the revision of former conclusions; old fallacies must succumb to new facts, and all things subserve to the development and establishment of truth.

The task which I have proposed to myself ultimately to accomplish is:—to describe severally the Oolitic beds occurring in the Northampton district, in the more northerly parts of the county, and in the neighbourhood of Stamford; to correlate the several

series; to exhibit fossils gathered from each; and thus to contribute somewhat towards the establishment of the character and sequence of the Oolites of this Midland District.

I purpose to divide my work into two or more Parts, and the present Memoir will constitute the first of these; but it is not improbable that the publication by the Geological Survey of their maps and memoir of the northern division of Northamptonshire (the work of that excellent geologist, Mr. Judd) may intervene, and render superfluous the completion of my scheme. In the meantime the following may not be unacceptable.

Part I.

The Oolites of Northampton and Neighbourhood.

Northamptonshire, from of old, has been said to be famous for "springs, spires, and squires." The first of these characteristics directly, and the others more remotely, are attributable to the geological features of the county.

The double alternation of pervious beds overlying impervious ones —the limestone of the Great Oolite upon its underlying clay, and the Northamptonshire Sand upon the clay of the Upper Lias—produces, at the outcrop of those beds upon the escarpments of the numerous valleys which intersect the county, the springs of pure water which formed the subject of the ancient boast.

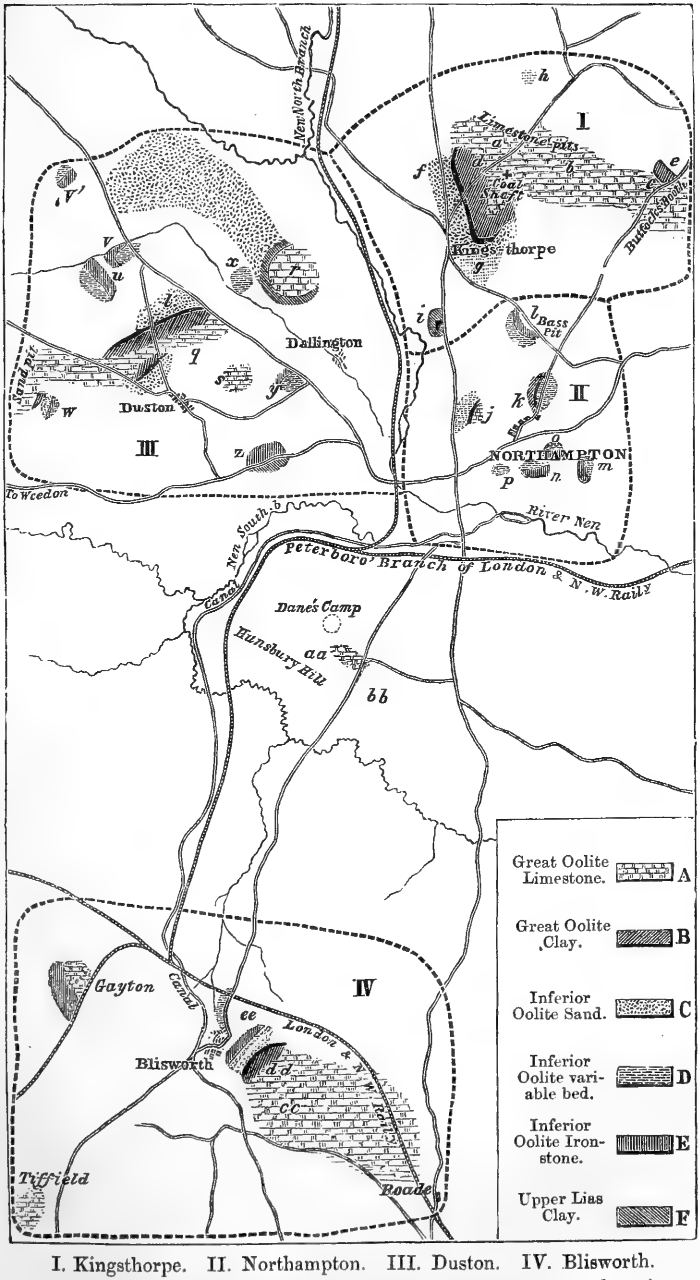
Then the variety of its soils (answering to the variety of the underlying materials), its fertility (attributable in part to natural irrigation), and the broad meadows with which its valleys are floored led at an early date to the general cultivation of its surface, and to its partition into small holdings or lordships: hence the numerous villages with which the county is packed, and the consequent churches and spires (built almost wholly of county Oolitic stone) with which it is studded.

Lastly, from the undulating character of its surface, and its fertility, eligible and beautiful sites for residences abound; and many such there are, with parks and "pleasaunces," (some of palatial importance,) constituting the ancestral homes of a numerous landed proprietary, and investing this Midland shire with not a little of dignity and beauty.

On the high grounds are commonly found deposits of Older Postglacial, or Glacial Drift, in the form, at some places, of gravel, and at others of Boulder-clay; which Drift-beds, having been cut through in the formation of the existing valleys, are therefore of a higher antiquity than they, and indicate that the causes which operated to produce the present surface contour originated subsequently to the Glacial period.

These numerous valleys have generally cut through the whole of the Oolitic beds, often deep into the Upper Lias, and in some instances even through the Marlstone into the Lower Lias; and this circumstance, and numerous excavations—in the shape of stone, slate, sand, ironstone, and clay pits, road-cuttings, and railway-cuttings—offer many facilities for geological investigation.

Fig. 1.—*Sketch Map of the Areas described.*



I. Kingsthorpe. II. Northampton. III. Duston. IV. Blisworth.
This Map is intended only to indicate the localities of the several sections referred to in this Memoir.

Thus there are four several areas within a comparatively small space (Fig. 1) in which the whole series of beds occurring in each, from the Great Oolite (including the same) down to the Upper Lias, are accessible; and these severally I propose to describe.

They are situated at or about:—1. Kingsthorpe; 2. Northampton; 3. Duston; 4. Blisworth. The individual beds of these several localities vary considerably; but collectively they may be said to present the following General Section, in which I have given maximum thicknesses in feet, and which, indeed, may be accepted as the typical section of a large portion of the county of Northampton:—

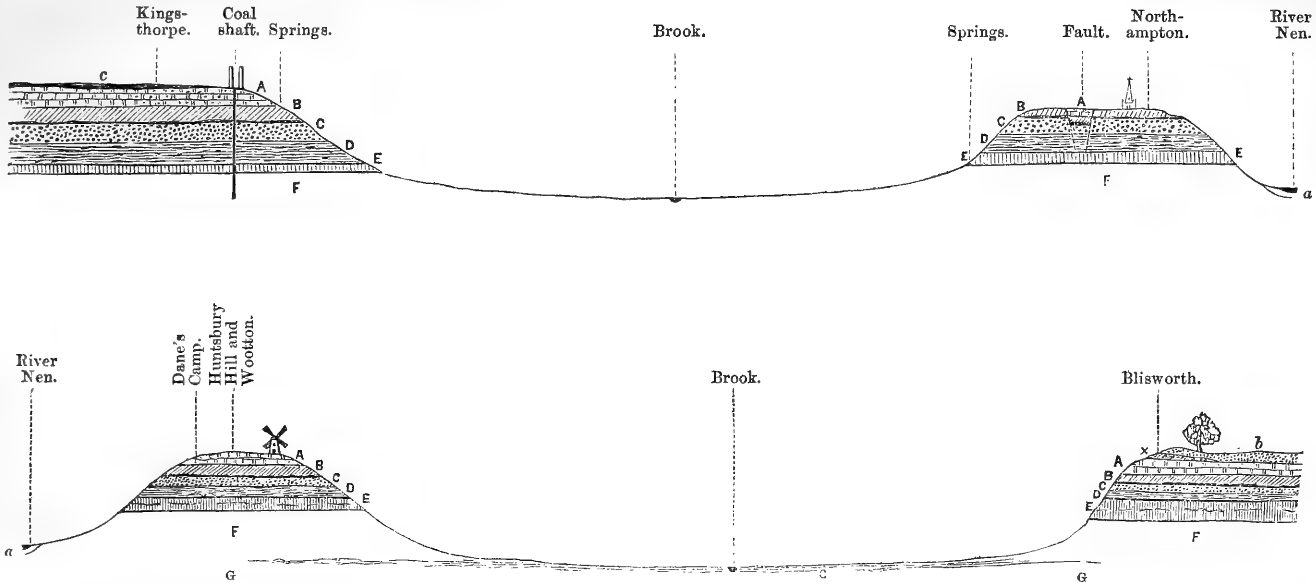
General Section of Oolitic Beds in the Northampton District.

			feet.
Great Oolite.	X	Stratified and variegated Clay at Blisworth, containing abundant *Ostrea subrugulosa*	2
	A	White Limestone, disposed in beds of from a few inches to about three feet in thickness, much fissured, varying in character, and containing characteristic Great-Oolite fossils	25
	B	Blue and Grey Clay, dug for brick-making, with ferruginous band at base, and Great-Oolite fossils	15
	XX	[Line of unconformity]	
Northampton Sand. Inferior Oolite.	C	White or Grey Sand, more or less coherent, and with occasional ferruginous stains—sometimes quarried for building stone. A plant-bed is usually found in this sand	12
	D	A series of very variable beds, composed sometimes of ferruginous sandstone in thin layers, which overlie calcareous beds containing shelly zones, false bedding being frequent: sometimes the whole section consists of calcareous rock with false bedding; sometimes it presents a series of beds of compact ferruginous sandstone, with no fossils. In one instance, the entire section consists of white sand and sandstone, with no fossils	30
		Coarse Oolitic or subcrystalline Limestone, with fossils, overlying a calcareo-arenaceous slate, like Collyweston slate	4
	E	Beds, chiefly consisting of Ironstone, containing *Rhynchonella variabilis*, and *R. cynocephala*, and *Ammonites bifrons* at the base	35
		Upper Lias Clay.	

I have provisionally distinguished the beds of D and E in this section, because I think I have evidence in the Northampton and Duston areas and elsewhere to justify me in so doing: the particulars of this I will give in my description of the beds of those areas. I admit, however, that the beds of E may be simply the lowest beds of D under another and local phase of conditions; but in this case a considerable addition must be made to the thickness of D.

Lists of Fossils from the several localities are given in Tables at the end of the Memoir.

Fig. 2.—*Section from Kingsthorpe, through Northampton and Huntsbury Hill, to Blisworth.*



a. Alluvium. *b*. Boulder-clay. *c*. Older Postglacial gravel. X. Great Oolite clay, Blisworth. A. Great Oolite limestone. B. Great Oolite clay, with ferruginous band at base. C. Inferior Oolite sand. D. Inferior Oolite, variable bed. E. Inferior Oolite ironstone. F. Upper Lias clay. G. Marlstone.

Area I. Kingsthorpe.

This area lies immediately north of Northampton. Its north-western portion consists of high ground capped with the White Limestone of the Great Oolite (A) overlain by a thin covering of older Post-Glacial or Glacial Gravel. This limestone is disposed in horizontal strata, and occupies an area of elongated irregular form, extending for about two miles, in a south-easterly direction nearly to Weston Favel, with an average width of about half a mile.

North of a road running easterly towards Moulton are large pits in this limestone (marked *a* on the map), presenting a section of about 25 feet. At the third of a mile south-east of these is another pit (*b*), the section of which, partly by the thinning of the limestone, and partly from denudation, has diminished to about 16 feet; and at the further distance of a mile in the same direction (near Buttock's Booth) is a third pit (*c*), in which the section is only about five feet.

The section of the pits marked *a* is as follows.

Section of Great Oolite Limestone at Kingsthorpe—giving Quarrymen's Terms.

	ft. in. ft. in.
1. Soft marly bed, with fragmentary masses of limestone, and fossils—*Gryphæa, Modiola*, &c.	*nil* to 4 0
2. Marly limestone, sometimes soft, occasionally hard—a few fossils	2 0 to 3 0
3. "Dirt Bed"—earthy shale bed, in thin layers, containing flattened bivalves, the tests preserved	1 0 to 1 6
4. "Top Soft Bed"—soft, marly limestone, containing large *Pholadomyæ, Homomya, Myacites, Ostrea subrugulosa, Natica, Clypeus*, &c.	1 0 to 1 6
5. "Pendle"—two marly limestone beds, each from 12 to 18 inches in thickness, the upper softer and more fossiliferous than the lower	2 0 to 3 0
6. Cream-coloured soft clay-like seam, with fossils	3 to 6
7. "Paving"—upper bed—hard, sometimes crystalline limestone, occasionally with blue heart, very full of fossils—*Alaria, Nerinæa, Astarte elegans, Trigonia, Acrosalenia, Clypeus*, palatal teeth of fish, &c.	2 0 to 2 6
8. "Paving"—lower bed—similar to the last, but not so fossiliferous	2 0 to 2 3
The "Paving"-beds stone is sawn up and faced, for floors, steps, window-sills, chimney-pieces, &c.	
9. "Top Jubs"—soft marly stone, full of *Pholadomya, Modiola, Natica*, large *Nautilus*, large *Clypeus*, &c., with a zone at bottom, softer, but containing the same fossils	2 6 to 3 0
10. "Bottom Jubs"—stone similar to the last, but softer	2 0 to 2 6
11. Lower zone of the "Bottom Jubs"—more compact limestone, rather coarsely oolitic in places, containing, among other fossils, *Nautilus Baberi, N. subtruncatus*, and numerous *Ostrea Sowerbyi*, the tests of which are perfect in the soft material of the bedding	1 0 to 1 3
12. "Bottom Soft Bed"—soft marly bed, with numerous *Rhynchonella concinna, Modiola imbricata*, &c.	1 0 to 1 6

The last bed is not well seen in the pits *a*.

Among the points of interest in this section are :—

1. The "Dirt Bed" (no. 3), which is of very similar character to the "shaly" bed at Tinkler's pit at Stamford, noticed by Professor Morris in the typical section of the Stamford Oolites given in a note in his paper in the Journal for November 1853. This bed is evidence of a comparatively brief but marked change in the local conditions during the period of its deposit.

2. The "Paving Beds" (nos. 7 & 8): these exhibit on the joint-surfaces the peculiarity of the fossils being thrown out into strong relief by the partial solution of the softer calcareous matrix, probably by the action of water charged with carbonic acid.

3. The zone of *Ostrea Sowerbyi* in the "Bottom Jubs." This *Ostrea* occurs in some sections in great abundance in the underlying clay B.

As to the fossils contained in these beds, I would particularly refer to the cast of a large smooth Ammonite, some 15 inches in diameter, formerly in Miss Baker's collection (now in the British Museum, and as yet, I believe, undescribed*, two similar Ammonites having been obtained by me from the Great Oolite at Blisworth)—to a remarkable fish-jaw, I believe of *Lepidotus*—to the great number of fish-palates, some probably of *Strophodus magnus* and *S. subreticulatus*, and teeth of Saurians—to the abundance of large *Pholadomyœ*, *Pinna ampla*, *Naticœ*, *Nautilus Baberi*, and *N. subtruncatus*, *Clypeus Mülleri* and *C. Plotii*—and to the characteristic zone of *Rhynchonella concinna* at the base.

The section of the pit marked *b* shows a continuation of the beds of pits *a*; and it would be merely repetition to give it in detail. In this pit, however, the *Rhynchonella* zone at the base is usually accessible, and is sometimes seen to pass into the underlying blue clay B.

The same fossil forms which are abundant in pits *a* abound also in pit *b*. Here was found the remarkable *Pandanaceous* fruit figured and described by Mr. Carruthers, F.L.S., F.G.S., of the British Museum, in the Geological Magazine, April, 1868, under the name of *Kaidacarpum ooliticum*.

The chief characteristic of the Buttock's Booth pit (*c*), which exposes a section of the lower beds only of pits *a* and *b*, is an abundance of fruit of *Carpolithes*, fish-palates and saurian teeth, and remains of crustaceans of two varieties of *Eryma*, near to *E. elegans*, Opp. Osseous fragments of *Teleosaurus* have more than once been found here.

Underlying the limestone is a bed of blue or dark grey clay, B, of a thickness, ascertained by well-sinking, of 14 feet, which is also to be classed as Great Oolite. The junction of the limestone with, and indeed its passage down into, this clay, is to be seen in the bottom of the pit *b*. Here the zone of *Rhynchonella concinna* and *Modiola imbricata* extends into the Clay itself. The junction is also

* Since the reading of this Memoir, Mr. Etheridge has examined the Ammonite in the British Museum and identified it as an old and smooth individual of *Ammonites gracilis*, Buckman.

observable on the roadside at *d*, whence a spring flows, except during drought: springs occur at other points of the same junction; and a stream dividing Kingsthorpe and Northampton takes its rise from the same.

I have not obtained fossils from this Clay at Kingsthorpe, except at the point of junction, although frequently in other localities *Ostrea Sowerbyi* and some other Great Oolite fossils abound in it. Until recently, it was worked for brick-making at *e*, near Buttock's Booth.

Its base is marked by a ferruginous band of from a few inches to a foot in thickness, observable at its junction with the underlying sand at a pit immediately north of Kingsthorpe, on the Brixworth road, marked *f*, and at other places.

The pit last mentioned (*f*) is at the base of the hill between Kingsthorpe and the limestone quarries, and exposes a section of about 12 feet of a white or grey sand, C, *the Upper Division* of the Northampton Sand*. The line of junction with the clay above is irregular, affording evidence of an eroded surface, and marking an unconformable division between the Great and the Inferior Oolite—a division observable over a considerable area, and in perfect accordance with a certain important fact, to which I shall hereafter allude.

This Sand is stratified, exhibits in places ferruginous stains, and is occasionally varied by the occurrence of argillaceous bands and patches. It is more or less coherent, and sometimes so indurated as to make a very durable building-stone, formerly much quarried, many public and other buildings in Northampton having been constructed of it during the last century.

It yields no fossils; but near its base is a plant-bed: a band, from 6 inches to a foot in thickness, made up of thin horizontal layers of sand separated by dark laminæ (which, when first split, present a surface indented apparently with leaf- and stalk-markings, filled with vegetable matter), overlies a bed in which are what appear to be numerous vertical root-perforations, penetrating to a depth of from one foot to two feet.

Beneath the plant-bed is a somewhat ferruginous bed of dark brown sandstone, apparently unfossiliferous. This is the upper bed of the very variable series which I have grouped under D, as the *Middle Division of the Northampton Sand.*

A characteristic section of this series of beds may be seen in the Nursery or "Shittlewell" pit (*g*), a few hundred yards south of Kingsthorpe.

Section of the Nursery or Shittlewell Pit.

	ft.	in.
1. Very ferruginous Sandstone, in thin layers, sometimes shivered 3ft. to	4	0
2. Ferruginous Sand, sometimes indurated into stone	2	6

* For the division of the Northampton Sand into *Upper*, *Middle*, and *Lower*, see *Diagram* of General Section (p. 380).

	ft.	in.
3. A bed of a peculiar character, consisting of alternate layers of calcareous and arenaceous material, each about half an inch in thickness, the former standing out in ridges when weathered. These layers are sometimes horizonal, and sometimes much and variously inclined from false bedding	3	0
4. Hard, irregular, finely laminated, shelly zone, with much carbonate of lime—contains *Acrosalenia Lycettii* and many oysters and other shells. This zone is not constant	0	9
5. Thinly laminated bed of alternate layers (as bed 3), but the false-bedding much more marked, sometimes inclined from right to left, and sometimes from left to right, in alternate zones	2	0
6. Similar bed, not so finely laminated, and with false-bedding, uniform in direction and less marked. Some fossils	3	0
7. Hard arenaceous limestone, in two beds, false-bedded, and becoming slaty towards the bottom 5 ft. to	6	0

One noticeable peculiarity in this section is the prevalence of false-bedding, inclining frequently in opposite directions in alternate bands, indicative of strong and diverse aqueous currents during the process of deposition. Another is the perfect manner in which the tests of shells have been preserved in the sandy zones. This I have found to be the case elsewhere, and indeed generally, in such zones.

Prominently noticeable also is the presence of several vertical pipes, of from a few inches to nearly 3 feet in diameter, which have penetrated through the whole of the calcareous beds—doubtless the effect of the dissolving action of water charged with carbonic acid. These are to be seen in section on the face of the pit: they have been filled, partly with the arenaceous residuum of the rock, partly with the sand of bed no. 2, and partly with material brought down by percolation from above.

It is curious that in every case these pipes are bridged over by the layers of the ferruginous bed at the top of the section; upon the non-calcareous material of which, in its passage through it, the water charged with carbonic acid has had no solvent effect.

Another section of this division of the Northampton Sand is exposed in a pit near Boughton (marked *h*), at a distance of a mile and a half N.N.E. from this Nursery pit, and on the other side of the high ground in which are the pits first described. Here the section, about 20 feet in thickness, consists wholly of calcareous rock, divided into some half-dozen beds, containing few fossils, but showing false-bedding near the bottom.

The calcareous condition of these beds is persistent over a considerable area lying in this direction; and they are largely quarried for building-stone, which is very durable and of a good colour.

A few hundred yards south-west of the Nursery pit, is the Kingsthorpe brick-pit (*i*). Here is seen the base of the Northampton Sand immediately overlying the Upper Lias Clay. It presents a section of from 6 to 8 feet of the Northampton Sand, and supplies a continuation downwards of the section of the Nursery pit.

Under a bed of about two feet of weathered rubbly brown sandstone is a soft arenaceous bed (also about 2 feet thick) contain-

ing corals—among others, a peculiar branching coral, frequently occurring in the Stamford Oolite, but as yet, I believe, undescribed.

Beneath this is a bed of about two feet of calcareous rock, thinly stratified—and under all a bed (one foot thick) of ironstone, thickly studded with small bodies, which are either rolled pebbles or concretionary nodules. I am disposed to assign this and the overlying beds of this section to my Lower Division (E) of the Northampton Sand.

This ironstone bed is divided from the underlying blue clay of the Upper Lias by a zone of a few inches of mixed material.

I may here mention, in passing, that I obtained from this Upper Lias Clay the new species of Crustacean described and figured by Mr. H. Woodward, F.G.S., in his "Fourth Report" on Fossil Crustacea in the 'Transactions' of the British Association for 1868, and which he has done me the honour to name *Peneus Sharpii.* I have also obtained from the same clay a very large head, some vertebræ, and scutal plates, of a *Teleosaurus* of an undetermined species.

Before leaving this Kingsthorpe area, I would mention that, about thirty-five years ago, a shaft was sunk in search of coal, at a point near the summit of the high ground of Kingsthorpe (marked on the map with a ×). A depth of 967 feet was reached. At a depth of 860 feet, the blue clay of the Lower Lias was pierced, and is stated to have been succeeded by "80 feet of Sandstone, 12 feet of Red Marl, and 15 feet of Conglomerate," which are described upon the same authority as "New Red Sandstone;" but the authority I believe to be unreliable upon this point.

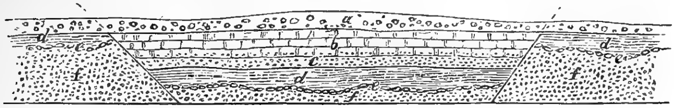
It will be a matter of surprise that a renewal of the attempt to find coal by means of this very shaft, should during the past year (1869) have been urged in the 'Mining Journal' and in a local newspaper, by a Mr. Ruglin, of Mexborough, near Sheffield, and that people should have been found who were disposed to listen to his suggestions.

Area II. Northampton.

In the area of Northampton, there is only one small spot (*j*) at which the Limestone of the Great Oolite (A) occurs; and it has been here preserved in consequence of a slight double or triple fault, which let down, some 5 or 6 feet below its normal level, a patch about 55 feet in diameter*. The whole area was afterwards planed over by denudation; and this remnant of the general bed of limestone was alone left, inlaid, as it were, in its underlying clay. This curious fact was only disclosed in November last, when, in the process of levelling land at the back of the borough goal for building-purposes, the following section was exposed:—

* Along the brow of the escarpment of the branching valley of the Nen river in this area, the upper beds are very much broken up by similar small faults, occasioned probably by the washing out of underlying soft or arenaceous beds.

Fig. 3.—*Section of double Fault in Northampton.*



	ft.	
a. Surface-soil	1	A
b. Limestone in thin broken layers, sometimes full of shells, chiefly *Ostrea*, and crystalline from the presence of carbonate of lime, having an irregular incline to the S.E.; at the bottom a softer zone, containing *Ostrea Sowerbyi* and large *Rhynchonella concinna*	3	A
c. Soft cream-coloured sand and clay-bed, full of *Ostrea Sowerbyi*	2	A
d. Blue clay, with ferruginous band (*e*)	2 to 3	B
f. White and grey sand with an admixture of clay, stratified, and ferruginous in places	up to 8	C

The presence here of the lower zone of limestone with *Rhynchonella concinna* and *Ostrea Sowerbyi*, and the blue clay with a well-marked ferruginous band at base, irregularly overlying the white and grey sand, completely identify this section with that at Kingsthorpe, notwithstanding that the blue clay (B) has thinned down from 14 feet to 3 feet.

About half a mile to the N.E. of this section, on the Kettering road, and close to the stand of the race-course, is a large pit (*k*), quarried for clay, sand, and building-stone. At the top of this section appears a cream-coloured clay, which I think may possibly be of Drift origin, and composed of the material of the denuded limestone. I am induced to suggest this by the fact of the very irregular surface (attributable to erosion) of the *Blue Clay* beneath (B); which varies in thickness from 1 to 3 feet, and appears somewhat disturbed in places. The ferruginous band, which elsewhere characteristically bases this clay, is observable also in this section.

The *Sand* (C) is here of the full thickness of 12 feet. It is much stratified and variegated in places, and upon the whole it is more ferruginous than I have found it in other sections. Some beds are hardened nearly into stone. The plant-bed occurs several feet above the bottom of the sand.

Beneath this sand, separated by a well-defined line, is a ferruginous sandstone, about 12 feet in thickness, disposed in five beds, the lower one of which is more ferruginous than those above it. These are upper beds of the series D; and, as in the case of the ferruginous sandstone basing the section of the sand-pit (*f*) at Kingsthorpe, they yield no fossils. I obtained, however, from this pit a ripple-marked slab of the ferruginous sandstone, upon the upper face of which is a film of the white sand. Evidently it is a fragment of the surface-material of the upper bed of this sandstone, and indicates a littoral or an estuarine condition of the area at the period represented by this junction.

About a quarter of a mile N. of this point is Mr. Bass's pit (*l*). The lower part of the last is represented, I think, in the upper beds of this section. The pit is excavated quite through the ferruginous beds, down to the Upper Lias.

So variable are the D beds here, that the excavation of a few yards will entirely alter the details of the section. Limestone will be replaced by sand, sand by ironstone, and either by limestone again, with every conceivable variation of change. A limestone band, however, about midway of the section, seems to be pretty constant—a circumstance frequently observable in other sections of this series, whether the beds above or below be calcareous or not.

With regard to the underlying series, E, I have observed much variation in thickness according to locality, but that, where any considerable development of thickness occurs, a greater uniformity of character is exhibited than in the D beds. I would note also, although the presence of iron in such proportion as to constitute iron-ore is generally the prominent feature of the beds E, that it is not uniformly so. Over a considerable area north of Northampton, the calcareous predominates over the ferruginous character of these beds. On the other hand, in some few localities, certain of the beds of D contain iron in sufficient quantity, probably, to render them available for smelting-purposes.

The following is the section of the pit at one point; and although it will not tally with the section at a few yards' distance, it will serve to give a general idea of one phase of the D and E series of beds.

Section of Mr. Bass's Pit.

	ft. in.	ft. in.
1. Very ferruginous sandstone, in thin layers		4 0
2. Soft ferruginous sandstone, in two beds, sometimes extracted in large blocks		4 0
3. Orange sand with rounded limestone masses		3 0
4. Flaky hard ironstone with ochreous cores	1 0 to	1 6
5. Coarse sand with thin layers of sandstone, rounded at the edges, with numerous fragments of shells, joints of *Pentacrinus*, &c.	1 0 to	2 0
6. Calcareous flaggy bed, blue-hearted, sometimes crystalline and very hard, containing *Rhynchonella cynocephala* (?) and numerous *R. variabilis*, and much wood	a few inches to	1 6
7. Red arenaceous stone		3 0
8. Ironstone in irregular beds, having a cellular texture with ochreous cores, varying in richness, and containing numerous shells in places	6 0 to	7 0
9. Limestone bed, with green centres, sometimes hard, and containing wood		1 0
10. An ironstone bed, with green argillaceous cores, full of rounded pebbles or concretionary nodules: this bed answers to the bottom bed of the Northampton Sand in the Kingsthorpe brick-pit *i*. It contains *Ammonites bifrons*		1 0

In this section, the points of interest are—the zone, no. 6, which contains more than one species of *Rhynchonella*, including *variabilis* and, I believe, *cynocephala*, and the lowest bed, no. 10, in which, not unfrequently, is found *Ammonites bifrons*. Mr. Judd has collected from a calcareous bed, 3 feet thick, immediately overlying the Upper Lias at Brixworth (probably answering to bed no. 9 in this section), a decisive example of *Rhynchonella cynocephala*.

The occurrence of these distinctive forms has induced me to include this *Rhynchonella* bed (no. 6) and all below it in my division E

and has impressed me, combined with considerations as to other areas, with the possibility that we have here a transitional bed connecting the Upper Lias and Inferior Oolite, equivalent to the similar bed (termed by Dr. Lycett "the *cynocephala* stage") of Frocester Hill and the Cotswold district.

I would here acknowledge the consideration and courtesy of Mr. Bass in preserving and presenting me with many fossils found in his pit.

Another good section of these beds is temporarily open on the premises of the County Lunatic Asylum, situated at *m*, at the eastern outskirt of Northampton, and about a mile and a quarter S.E. of Mr. Bass's pit. This will serve further to illustrate the variable character of these beds.

Section at the Northampton Lunatic Asylum.

	ft.	in.		ft.	in.
1. A series of fourteen or fifteen bands, from 4 to 6 inches in thickness, alternately orange sand and ferruginous stone, the latter slightly calcareous, an upper stone-band being very ferruginous				6	6
2. A variable bed, sometimes ferruginous sandstone, passing laterally within a few feet into a limestone, dug for building-purposes, contains coral, *Thamnastræa*, &c.	1	3	to	1	6
3. Hard flaggy ferruginous bed, somewhat calcareous	1	6	to	1	9
4. Calcareous band				0	9
5. Hard ironstone, in four or more bands of unequal and varying thickness, very fossiliferous, especially in the uppermost band				2	0
6. Softer and more arenaceous band, many shells				0	9
7. Rich ironstone, in twelve or more irregular bands, of cellular structure, having ochreous and sometimes argillaceous cores, with wood, and occasionally fossiliferous zones			about	6	0
8. Bed in blocks, green-hearted with oxidized surfaces on the planes of bedding and joints			about	1	6
9. Flaky ferruginous bed, with argillaceous cores, equivalent to the bed no. 10 in the last section			about	1	0

One set of joints in this section have a direction N.W. and S.E.; and the crevices are frequently filled with a soft white material, which, upon analysis by the recently deceased Dr. Berrill (formerly a student at the School of Mines), was shown to be allied to *allophane*.

The general coincidence of the *lower part* of this section with the same portion of the last, classed under E, is observable.

The fossils obtained by Dr. Berrill from this excavation have been courteously presented to me by the representatives of the lamented gentleman, who was cut off in early prime, and in the midst of an active career, by an attack of fever, in December last. A list of these fossils is given in the tables; but I may notice here the remarkable way in which delicate casts of the tests of *Trigoniæ*, *Tancredia axiniformis*, and some other small shells have been preserved (showing in the same specimens, perfectly, the exterior sculpture and the internal hinge), also impressions of a fragment of *Cidaris Fowleri* and of a spine of *Cidaris Wrightii*, the abundance of *Pinna cuneata*, and the state of preservation of many of the tests of the shells found.

About a quarter of a mile W. of this place, on the Billing road, at *n*, in digging out cellars for houses, a section of about 12 to 14 feet has been exposed, cut through a continuation of the ironstone beds of the Asylum section.

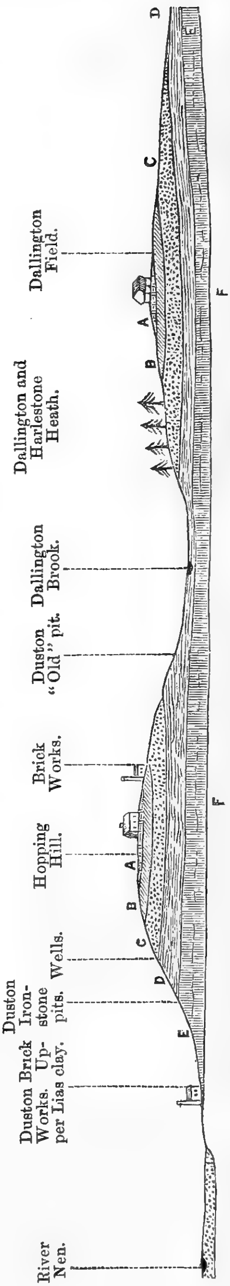
About midway of the section is a shelly zone about 8 or 10 inches in thickness, in which *Limæ* of several species (generally large) are very abundant, and indeed almost the only shells. At a level a little above this zone, corals (*Thamnastræa* and *Latomæandra Davidsoni*) occasionally occur. The soft white material of the last section is also found here.

Very near to the last spot, in Frith-street, at *o*, in excavating for building, several years ago, a section was opened analogous to the Asylum section, and containing very shelly zones. At a few feet from the top, a zone of coral (*Thamnastræa*), frequently in large masses, was found.

A similar zone was broken through, a short time since, in making a culvert in St. Giles's Street (*p*), and was here locally associated with *Pinna cuneata* and *Gervillia acuta*. Similar coral has been found at an intermediate point.

The junction of the Northampton Sand with the Upper Lias clay has produced in the town of Northampton many springs of ancient repute, such as Scarlet Well (in the old dyers' quarters), King's Well, St. John's Well, Becket's Well (named in mediæval times in commemoration of the last interview between Henry II. and the Archbishop, held at Northampton in A.D. 1164), and Nine Springs Head. The Water Company draw their supply chiefly from the Marlstone by a well, 168 feet deep, starting from a level about midway of the Asylum section.

Fig. 4.—*Section from Duston to Dallington.*



For explanation of letters see fig. 2.

Area III. Duston.

The parish of Duston lies immediately west of Northampton, from which it is separated by the river and valley of the Nen. Its highest ground is capped with Great Oolite Limestone, A, which is quarried at Hopping Hill (*q*), about two miles N.W. of Northampton, on the Dunchurch road, and extends from that point in an irregular band for about a mile and a half nearly due west.

At about three-quarters of a mile N.E. of *q*, a nearly circular patch of this limestone, about a quarter of a mile in diameter, occurs upon the opposite high ground of the Dallington lordship (*r*), a deep valley and the Dallington brook intervening.

At about half-a-mile S. of *q*, another patch is quarried at *s*. This is on a somewhat lower level, having been let down in the fork of a double fault, marked in the map of the Survey.

At Hopping Hill (*q*), the limestone pit presents a section of about 12 feet elevation, the fossils obtained being in the bulk identical with those found in the Kingsthorpe limestone, the exception being that *Pholadomya lyrata* and *P. Heraulti*, forms not common at Kingsthorpe, are here very abundant. The earthy shale-bed ("Dirt Bed") of Kingsthorpe is also present, but nearer the base than in the former section.

Section of Limestone A *at Hopping Hill.*

	ft. in.	ft. in.
1. Soft clay-like marl		2 0
2. Soft marly rock, in three layers of varying hardness, containing *Pholadomya lyrata* and *P. Heraulti*, &c.	1 6 to	2 0
3. Band of soft marl, very full of shells		0 9
4. Hard marly rock, with few shells		1 0
5. Compact arenaceous stone, somewhat calcareous, with few shells, *Ostrea costata*, &c.		1 3
6. Earthy shale-bed ("dirt-bed") in thin layers, containing flattened bivalves, chiefly *Ostrea*		1 0
7. Ditto, more argillaceous, and paler and greyer in colour		1 0
8. Very hard limestone, with blue heart, *Rhynchonella concinna* &c.		1 6
9. Soft limestone, very full of shells, *Rhynchonella concinna*, *Modiola imbricata*, *Natica* various species, large *Nautili*, *Clypeus*, &c.		1 6
Blue brick-clay at base.		

At *t*, a little more than a furlong N.W. of the limestone-pit *q*, and on the N.W. incline of Hopping Hill, the underlying blue clay B is worked for bricks. It is here about 8 feet thick: at the top of the section is seen its junction with the overlying bottom soft bed of the limestone, and at the base the characteristic ferruginous band observable in the two former areas. This clay has occasional bituminous and woody bands and patches, but has yielded no other fossils.

In the same brick-field, within a very few yards, the underlying white sand C is dug to a depth of about 6 feet, but has not been bottomed. I have not found here the plant-bed, which probably has not been reached.

This sand forms the surface-bed over a considerably area of the opposite high ground to the N. and N.W., constituting the Dallington and Harlestone Heaths.

At a distance of three-quarters of a mile due W. of Hopping Hill, at *u*, is the very ancient and large "Old" Duston stone-pit, which presents a characteristic section of some 40 feet elevation.

At the top of the section, at the eastern extremity of the pit, is the white sand C, reaching a thickness in some places of 4 feet: this thins away, and is absent in the southern portion of the same section. At the base of this sand is the plant-bed, with vertical perforations, in what is here a slightly ferruginous and very friable sandstone. Beneath this are some 12 feet of the variable beds D, overlying 4 feet of coarse limestone and slaty beds; and below, from 18 to 20 feet of the lower beds, E, of the Northampton Sand.

The following are the details of the section as recently exposed:—

Section of Old Duston Stone-pit, giving Quarrymen's Terms.

		ft. in.	ft. in.
1.	White sand	*nil* to	4 0
2.	Brown soft sandstone, with vertical plant-markings ("root-perforations"?)	*nil* to	1 6
3.	"The Roylands"—a series of beds, each from 6 to 9 inches in thickness, very variable, sometimes hard, in which condition it is "best" building-stone, and sometimes "caly" or crumbling. These beds occur in two divisions, the building-stone of the upper being of a rich red-brown colour, and of the latter of a colder fawny-brown colour. Wood is frequently found, and I obtained from these beds a slab ripple-marked; sandy zones also occur, in which the tests of shells are perfectly preserved	9 0 to	10 0
4.	Orange sand, with rounded cores of arenaceous limestone, the remains probably of the original bed after being subjected to the action of water charged with carbonic acid	1 6 to	2 0
5.	"White Pendle"—in two beds:—		
	a. Coarsely granulated limestone, made up sometimes of oolitic grains in a matrix of calcareous cement, sometimes of crystalline angular particles with comminuted shells, more or less arenaceous in places, and containing *Belemnites*, large *Lima* nov. sp., large *Hinnites abjectus*, &c.	2 0 to	3 0
	b. Arenaceous and calcareous slaty beds, very like to, and called by the pitmen, "Colleyweston slate"	2 0 to	3 0
6.	"The Yellow" building-stone—consisting of six or seven beds of varying thickness, in two divisions, differing somewhat in tone of colour; these beds contain "pot-lids" of ironstone, also *Cardium cognatum* &c.	6 0 to	7 0
7.	"Best Brown Hard" building-stone, in three or four beds—a coarser, stronger stone than that of the other beds, but of a rich red-brown colour: it contains few fossils		6 0
8.	"Rough Rag"—a slightly calcareous sandstone, green-hearted, hard and durable, used for copings, gravestones, and building: it contains *Ammonites Murchisonæ*, *A. opalinus*, *Nautilus*, *Ceromya bajociana*, *Pholadomya fidicula*, *Cardium cognatum*, *Cucullæa*, &c., and a characteristic zone of *Astarte elegans*		3 0
9.	"Hard Blue"—a very hard blue-hearted stone, the surfaces of joints and bedding brown from oxidation: it contains the same fossils as the last bed, no. 8, excepting *Ammonites Murchisonæ* and the *Astarte-elegans* zone	3 0 to	4 0
10.	The presence of water prevents the working of the stone in this pit to a lower depth; but in an old unused pit in an adjoining field the beds for about three feet lower are exposed; and these consist of cellular ironstone, having sometimes green arenaceous, and sometimes ochreous cores		3 0

It will have been observed that in "The Roylands," bed no. 3, much wood, and slabs ripple-marked, have been found. These, I take it, indicate estuarine or littoral conditions during the period of deposition.

In the "White Pendle," no. 5, we have a prominent example of the limestone and slaty beds which I have found to occur at different points over a considerable area in the same position in the general section of the district. The calcareous nature of these beds, and the slaty character of the so-called "Colleyweston Slate" (no. 5, *b*), and indeed of the Colleyweston Slate itself, I consider to be attributable to accidental and local causes, as are also, within more limited areas, the remarkable variations upon the same horizon in beds described in former sections; but I cannot but think that the persistency of this limestone band over a considerable local area indicates a passage in time, an alteration in the depth of the aqueous bottom, and possibly a change to more marine conditions, which raise that band above the synchronous and patchy variations so frequent in the beds of D. This persistency, although sometimes the slate bed and sometimes both beds have been wanting, has induced me, for my own guidance, to adopt these beds as a mark of separation between what I consider to be the Middle Division (D) and the Lower Division (E) of the Northampton Sand.

At a distance of a few hundred yards from this Duston "Old" pit, is the "Old Slate-quarry Close." Here a stone-pit (*v*) was opened a few years since, which exposed some of the old workings, carried on, at some unknown distant time, for the obtaining of slate alone. The old process was that still sometimes adopted at Colleyweston, and called "foxing." Shafts were sunk, and the slate was extracted from beneath the overlying beds by means of adits.

The section of this pit has a less elevation than that of the "Old pit;" and the beds are imperfect continuations of those of the latter, exhibiting traces of both natural and artificial disturbance. The characteristic and crowded zone of *Astarte elegans* of the "Rough Rag," no. 5, of the last section, is continued into this section. I have also found this zone in two other sections in the Duston area, presently to be described, severally a mile and a half and two miles from this point, and also at the Harlestone pits, at *v'*, more than a mile to the north-east of Duston "Old" pit; so that this *Astarte-elegans* zone extends over an area at least three miles in diameter in one direction.

I have to thank the proprietor of these two stone-pits (Mr. Samuel Golby) for information communicated by, and fossils received from him.

In a small pit temporarily opened at a short distance east of *v*, I obtained from the limestone-bed no. 5 *a*, a very perfect tooth of *Megalosaurus*.

About a mile south of the "Old" Duston pit (at *w*), upon the escarpment of the hill overlooking the wide valley, some four miles in breadth, traversed by the southern branch of the river Nen, and by the main line of the London and North-Western Railway, (in which

valley, at the borders the Upper Lias, over the main-flat the Middle Lias, and in a narrow central band the Lower Lias, are in succession the surface-beds,) is a pit in the division D. The section here is about 30 feet in elevation, and consists entirely of white sand and sandstone, in which no fossils have been found. Some of the lower beds of this section are seen in the low side-section to pass into slightly ferruginous sandstone, some fractured surfaces of which, when held in one direction towards the light, present a peculiar lustre, proceeding from innumerable minute facets of crystals of carbonate of lime.

To return to the neighbourhood of Hopping Hill—upon the Dallington side of the valley and brook already referred to, is an old stone-pit at *x*, which presents a section of about 25 feet elevation, consisting entirely of compact brown sandstone, in seven or eight beds, yielding no fossils—precisely the material of the white sandstone of *w*, *plus* the ferruginous colouring.

Again, at *y*, three-quarters of a mile S.E. of Hopping Hill, is a recently opened pit, just showing at one extremity the White Sand C, and beneath this the following section:—

Section of Pit on the Dallington and Duston Road.

	ft.
1. Coarse sand (decomposed sandstone?)	1
2. Very broken sandstone	6
3. Flaggy sandstone, slightly calcareous	4
4. Sandstone in beds of from a few inches to two feet thickness	7 to 8

All brown from ferruginous colouring—no fossils.

At a few yards from this spot, and at nearly the same surface-level, two wells have been sunk through 68 feet, by admeasurement, of ferruginous rock, without dipping into the Upper Lias. In these wells, at some depth below the base of the above pit, the *Astarte-elegans* zone was penetrated.

I have obtained from the well-sinker the following rough statement of the section of these wells:—

Section of Wells at Duston.

	About ft.
1. Red "rammell" and sand	14
2. Red Rock, in various beds	14
[From some materials which I obtained when the well was sunk, I assume that the zones of limestone and slate occur in these beds.]	
3. Red Rock, in three courses, very full of fossils	7
[The *Astarte* zone, of which I obtained a large block, occurs in one of these courses.]	
4. Red "Freestone"	14
5. Ironstone	8
6. Green Rock ["like the lower beds of Duston Ironstone"]	8

The Green Rock was not bottomed, plenty of water being obtainable, but forms the flooring of the well.

The above thicknesses were only *estimated* by the well-sinker,

and, in the aggregate, fall short by 3 feet of the measured depth of the well.

A quarter of a mile north of this point, and a mile and three quarters from Duston "Old" pit, in my own garden, at a lower level than *y*, the limestone bed overlying the slate bed (no. 5, *a* and *b*, of "Old" Duston) occurs; and below, but not immediately, is found cellular ironstone with ochreous cores.

At a mile S.E. of Hopping Hill, and at a little more than a mile west of Northampton, in the angle formed by the junction of the roads to Weedon and Duston, is perhaps the most important ironstone quarry in Northamptonshire. During the last eleven years the excavations, varying in depth from 25 to 35 feet, have been extended over an area of about 16 acres. (See *z*.)

The whole section belongs to my division E, and consists of ironstone of varying richness. I have noted the section some five times at various intervals, but have found no very great variation in the character and order of the different beds; and in this respect they offer a striking contrast to the D beds of Mr. Bass's pit, the variation in which is so remarkable.

These beds are very fertile in organic remains; and, through the intelligent and watchful assiduity of Mr. Eldret, the overlooker of the works, I have been enabled to obtain from this quarry a large collection of fossils, upon the significance and importance of which it is needless, and would be out of place, for me to dilate. I have often paid my thanks to Mr. Eldret; and I think the thanks of geologists generally are due to him, but for whose active interest in the preservation of these fossils they would certainly have been consigned to the smelting-furnace, and thus lost to geological science.

A great part of the area of excavation was the site of a Roman burial-ground; and, through the agency of the same Mr. Eldret, I have obtained many interesting Roman and Romano-British antiquities, with which the surface-soil and underlying disturbed material abounded.

The surface-soil is generally about three feet in thickness, but, from ancient disturbance, is frequently mixed up with the material of the upper bed of the ironstone—this disturbance having penetrated to irregular depths, frequently of 6 feet.

The following are the particulars of a recently exposed section:—

Section of Ironstone at Duston Quarry.

	ft.	in.
1. Surface soil and rubbly ironstone, mixed by disturbance and very irregular, with zone of *Cardium cognatum* or *Buckmani* at bottom	6	0
2. Stratified cellular ironstone with ochreous cores, in thin layers......	3	0
3. Ironstone, more sandy and very shelly, with large *Nautilus* (*obesus*), *Ammonites Murchisonæ* and *A. corrugatus*, *Pholadomya fidicula*, *Cardia*, &c.	3	0
4. Rich cellular ironstone with sandy cores—zone of *Astarte elegans*, *Trigoniæ*, *Ceromyæ*, and many other shells	1	0
5. Bed in blocks of sandstone, oxidized upon joint and bedding planes	1	0
6. Very rich cellular ironstone, containing many corals: from this bed		

ft. in. ft. in.

was obtained the remarkable new starfish, *Stellaster Sharpii*, Wright*, also *Astarte minimus* in clusters, *Rhynchonella variabilis*, *Terebratula perovalis*, *T. ovoides*, &c. 1 6

7. Ironstone containing plants, *Acrosalenia*, &c. 1 0
8. "Sand-bed"—coarsely cellular ironstone, with sandy cores—sometimes hard sandstone—containing few fossils 1 6
9. "Four-foot bed"—cellular ironstone, with ochreous and argillaceous cores, in many layers and very crumbling, alternating frequently with irregular arenaceous bands, sometimes 2 feet in thickness, and exceedingly fossiliferous—*Hinnites abjectus*, *Pecten*, *Ammonites*, *Rhynchonella*, &c. .... 4 0 to 6 0
10. Variable beds, with very green cores, oxidized on the joint and bedding planes, in thinner bands at the top and towards the bottom, occasionally very rich in fossils, the tests sometimes preserved—Coral, *Lima* (various species), *Pecten articulatus*, wood, &c. Of the larger blocks, the iron-ore coating only is used for smelting 8 0 to 9 0
11. Much broken ferruginous beds, not worked because of water, and little known: a zone at bottom, exposed in the section of a neighbouring clay-pit, is probably equivalent to the *Ammonites-bifrons* zone, the bottom bed of Bass's pit. I have an example of *A. bifrons* said to have been obtained from this pit, but upon doubtful authority. The lowest zone contains numerous rounded pebbles or concretionary nodules.. about 3 0
12. Band of mixed material, as at Kingsthorpe brick-pit 0 6

Upper Lias Clay.

Although I have associated in this section certain beds with certain fossils generally found in them, yet this association must not be understood to amount to a limitation. The more abundant fossils, such as *Cardium cognatum*, *Isocardia cordata* and a large new species, *Ceromya bajociana*, *Lima* (various species), *Cucullæa* (various species), *Macrodon hirsonensis*, *Trigonia* (various species), *Pecten demissus*, *P. lens*, and some other forms, are found almost indifferently, but irregularly, in all the beds of the section.

A certain significance, however (to which I have already alluded), attaches to the position in this section of the zone of *Astarte elegans*, having immediately above it a bed containing *Ammonites Murchisonæ* and *Pholadomya fidicula*. It will be remembered that a similar zone occurs in the Old Duston, Old Slate Quarry, and Harlestone stone-pits (u, v, and v'), marked by the presence of the same Ammonite and bivalve—and also in the wells near Hopping Hill, at about the same distance from the surface as in the Old Duston pit. The occurrence of such a zone at these five different points, thus marked at two of them by the presence of *Ammonites Murchisonæ* and *Pholadomya fidicula*, would seem to point to the conclusion that it represents an horizon within this area, and to the equivalence within the same area of the beds (at whatever points found) lying between this zone and the Upper Lias Clay, especially as the thickness of the ferruginous beds penetrated by the wells (near y) is more than equal to the entire thickness of the Old Duston pit section down to the *Astarte* zone added to the thickness of the Duston ironstone pit section from the *Astarte* zone down to the Upper Lias clay,—that is,

* *Vide* Note by Dr. Thomas Wright, F.R.S.E., F.G.S., appended to this Memoir.

to the total thickness of D and E, the sequence of the beds of the wells-section being also favourable to such an assumption.

It is noticeable, however, that at the "Old" Duston pit the green colouring of the beds begins with the *Astarte* zone, while in this Ironstone section it is only observable lower down. The absence of the green colouring in the higher beds of both sections is probably due to oxidation, the effect of atmospheric influence. In the "old" pit, a very thick mass of rock is superimposed upon the *Astarte* zone; and consequently such atmospheric influence has not permeated that and lower beds; but in the Ironstone quarry the *Astarte* zone lies comparatively near to the surface, and considerably above the level to which that influence has penetrated. This difference in circumstances of position will probably account for the apparent discrepancy in the range of the green colouring of the beds in different sections.

The parallelism of these beds with the lower beds of Bass's pit (*l*) is not only suggested by position, but is confirmed by the fact of the identity of some characteristic fossils found in both sections, notwithstanding the absence from the last-named pit of the *Astarte* zone: for instance, in the lower beds of Bass's pit are found two large species of *Pleurotomaria* (*armata*? and a species near to *Marcousana* of D'Orbigny); and the same forms (unmistakably identical with those from Bass's pit) occur in the Duston Ironstone beds. The lowest bed, also, like that in the last-named pit and in the Kingsthorpe pit, is full of rounded pebbles or concretionary nodules.

That these beds are not higher up than the Inferior Oolite is abundantly shown by the fossils exhibited; while the view that these beds are possibly equivalent to Dr. Wright's Frocester Cephalopoda beds is strengthened by the occurrence of *Ammonites jurensis* (?), and in three other pits of *Rhynchonella cynocephala*; and that they have a transitional character, by the probable presence of *Pholadomya ambigua*, *Ammonites bifrons*, *A. opalinus*, and some other fossils which would tend to such a conclusion.

It cannot be conceived that there could have been a point in time at which the period of the Upper Lias definitely ceased and the period of the Inferior Oolite as definitely commenced. One must have merged into the other, and life-forms have been gradually transmuted into or superseded by other life-forms, during a connecting period of longer or shorter duration; and my suggestion is, that we have in the lower beds of the Northampton Sand a stratigraphical representative of a portion of such transitional interval *.

Before leaving this remarkable section, I may be excused if I offer a few words upon the ferruginous character of these beds. I need not say that they are not in their original condition. The numerous living organisms of which these fossils (many of them, as it were, cast in iron) are the enduring monuments, could not possibly have existed in waters charged with iron to the degree apparently indicated by the present condition of the rock. The iron must have been introduced after the deposition of the sedimentary

* See Dr. Lycett's opinion in note to the Blisworth Area.

material,—by infiltration doubtless; but whence derived, is a problem yet, I think, to be solved.

The beds have thus undergone *change*—have been *doubly* metamorphosed,—first in the introduction of the iron, and secondly in the altered form in which the iron is now exhibited in the cellular ironstone.

There can be little doubt that at some period the iron, subject to local variations as to proportion, was equably diffused throughout the mass of impregnated material (even as now it is in the slightly ferruginous brown sandstones of the Northampton beds): it afterwards, in obedience to some subtle principle yet to be determined, separated from the associated material, and arranged itself as walls of cells, ever varying in form (some being rectangular, many irregular and many-sided and often with rounded angles, some nearly spherical, and occasionally concentric), but all containing cores of the original material—whether sand, marl, or clay—from the majority of which the iron has almost entirely departed.

The quantity of iron present in these beds offers also a fertile subject for consideration. The ore yields on an average 40 per cent. of pig-iron—sometimes more than 55 per cent. From this Duston pit alone, more than 1000 tons of ore per week are sent away; and the *weekly* produce from the county of Northampton is from 9000 to 10,000 tons, yielding from 3000 to 4000 tons of pig-iron. This has been going on for some ten or twelve years, certainly not always at the same rate as now; but were we to dot out on the map the comparatively few excavations from which already such an immense amount of iron has been obtained (say a million and a half of tons), and compare the area of these with the whole area occupied by the ferruginous beds of the county, we should arrive at such an idea of the aggregate quantity of iron imported into these beds subsequently to their deposition, as to involve in considerable difficulty the question of its derivation and of the conditions under which it was introduced.

South of Duston is the east and west branch of the valley of the Nen, and immediately south of Northampton is the conflux of this branch with the northern branch of the same valley. About two miles west of this point commence thick alluvial beds, which occupy, with a bordering of Upper Lias Clay, the Nen valley and its tributaries for many miles to the east and north-east. The upper bed here consists of an earthy clay with much vegetable matter; and in its lower portion it is spotted bright blue by nodules of *Vivianite* or *phosphate of iron*: it contains at its base numerous remains of ox, deer, horse, and wild boar, frequently stained blue by the same mineral. The lower bed consists of a sandy gravel, from which I have obtained teeth of *Elephas antiquus* and *primigenius*, bones of *Hippopotamus*, and teeth both of the upper and lower jaws of *Rhinoceros tichorhinus*. This alluvium overlies the Upper Lias clay.

On the southern side of the valley is Huntsbury Hill, a projecting

headland, occupying the angle formed by the junction of the Nen valley with the broad valley through which passes the London and North-western railway. The road from Northampton to Blisworth ascends this hill, and passes over the junction of the Upper Lias with the lower beds of the Northampton Sand, marked by the presence of springs. On the ridge, near the Danes' Camp, is a small patch of Great Oolite Limestone at *aa*; and upon the descent on the southern side, at *bb*, the junction of the white sand C with the beds D is observable. In the valley below, the Marlstone of the Middle Lias is the prominent surface-bed.

At a distance of five miles from Northampton, in this direction, is

Area IV. Blisworth.

The general section of this area varies in some particulars from that of each of the areas I have yet described. The high grounds are capped with a thick bed of Boulder-clay, containing rounded boulders of primary rocks, fragments of chalk and flints, masses of *Septaria*, rounded blocks of indurated Oxford Clay enclosing numerous Ammonites and other fossils, &c.

Between the Boulder-clay and the underlying Great Oolite Limestone, A, is a bed of very variegated and thinly stratified Great-Oolite clay, very full of small oysters (*Ostrea subrugulosa*). This clay occurs also in the same position at Tiffield, about two miles S.W., and at Stowe Nine Churches, some six miles west. At the latter place it is seen at the top of the section of a mass of Great Oolite let down by a fault below the level of the neighbouring ironstone; the wall of which fault, sharply defined, is seen in the quarry. I have indicated the place of this clay in my General Section by the letter X.

Another variation consists in the remarkable thinning of all the beds between the Great-Oolite limestone, A, and the lower beds, E, of the Northampton Sand. These beds, B, C, D, which represent in the General Section an aggregate thickness of from 55 to 60 feet, have here dwindled to a thickness only of from 8 to 10 feet. They have again thickened, however, in districts S. & S.W. of Blisworth.

A section of the Great-Oolite limestone is graphically seen in the cutting of the railway between the Blisworth and Roade stations; but it may be more particularly examined in the ancient and large quarry to the S.E. of the village. This quarry is approached from a point near to the N.E. entrance of the great tunnel of the Grand Junction Canal; which tunnel, cut to a length of nearly two miles in the Upper Lias clay, constituted one of the great engineering works of the last age.

The following is the section in this quarry:—

Section of the Blisworth Great-Oolite Limestone Quarry, with Quarrymen's Terms.

	ft. in.		ft. in.
1. Boulder-clay	11 0	to	12 0
2. "Rammel"—clay, very variegated (green, yellow, brown, blue, and black), thinly stratified, full of *Ostrea subrugulosa*, and containing wood	1 6	to	2 0

	ft.	in.		ft.	in.
3. "Pendle"—consisting of hard close limestone, very heavy and blue-hearted (a good rough building-stone), and of slaty or flaggy beds	4	6	to	5	6
The "Pendle" is divided into four divisions or beds: the upper two are each from 15 to 18 inches thick; beneath them is a bed of flags in about six layers, each 6 to 9 inches thick; and below this is another bed of about the same thickness and character as the upper beds. A zone at the bottom of the last occasionally abounds with *Echinobrissus*, *Acrosalenia*, &c.					
4. Sandy band in thin layers, which sometimes assumes the character of an earthy shale-bed, and is sometimes argillaceous, containing numerous oysters having the shells preserved, and occasionally fish-palates	0	9	to	1	0
5. "Marly bed"—soft calcareous material, burnt for lime—in two divisions, and containing numerous *Pholadomyæ*	2	0	to	2	6
6. "Sandstone"—an arenaceous limestone, soft, but hardening upon exposure—a good building-stone—in two divisions, and containing few fossils	3	0	to	4	0
7. "Bottom marly bed"—very soft and "rammelly," burnt for lime, very full of fossils—*Terebratula maxillata* (very perfect), *Modiola imbricata*, *Acrosalenia*, &c.	3	0	to	3	6
8. Soft clayey band, with the same fossils, and fish-palates	0	6	to	0	9
9. "The Blocks"—open, freely working oolitic limestone—sawn up and faced for flooring, window-sills, chimney-pieces, &c.—contains *Nautilus Baberi*, *N. subtruncatus*, *Clypeus Mülleri*, and *C. Plotii*	2	6	to	3	0
I have also obtained from this bed two specimens of a large smooth Ammonite, about 16 inches in diameter, probably of the same species as that from Kingsthorpe in the Baker collection in the British Museum, referred to in my description of that section*.					
10. Very hard blue-hearted stone, with some fossils	1	0	to	1	3
11. Blue Clay	1	0	to	2	0
12. Blue close stone, much fissured, and with very open joints	1	0	to	1	6
13. Blue Clay.					

The last three beds are below the level of the ordinary working, and are given only upon the report of the quarrymen.

I have from this quarry (I think from one of the beds of the "Pendle," No. 3) a fish, *Pholidophorus Flesheri*, Ag. Agassiz describes and figures an example of this fish (Poissons Fossiles, tom. 2, p. 281, t. 37. fig. 8), but gives as its bed and locality the "Inferior Oolite, Blisworth." I have a strong impression, favoured by the appearance of the figure and its matrix in the plate, that Agassiz's fish came from the same bed as mine, and that his, as well as my fish, belongs to the fauna of the Great, and not of the Inferior, Oolite.

About a quarter of a mile N.W. of the Limestone Quarry is the Blisworth Ironstone Pit at *d d*; of which the following is a section:—

Section of Ironstone Pit at Blisworth.

	ft.	in.
1. Surface soil	1	0
2. Soft calcareous marl—decomposed limestone (?)	1	6
3. Hard limestone, somewhat shivered	1	3

* One of these Ammonites has been identified by Professor Morris, F.G.S., as an old and smooth example of *A. gracilis*, Buckman.

	ft. in.	ft. in.
4. Soft marly bed, with *Ostrea Sowerbyi* abundant		1 0
5. Compact marly limestone		2 3
6. Marly limestone, very soft, with *Ostrea Sowerbyi*, large *Trigonia Moretoni*, *Modiola*, and other Great-Oolite fossils		1 3
7. Dark-grey clay, with numerous *Ostrea Sowerbyi*		1 6
8. Ironstone band, with *Ostrea Sowerbyi*, *Modiola imbricata*, *Pteroperna plana*, *Perna rugosa*, var. *quadrata*, *Natica* (*Euspira*) *pyramidata*, &c.	0 9 to	1 0
9. Very variable sandy clay, sometimes more arenaceous than argillaceous, with vertical plant-markings	2 0 to	3 0
10. Orange sand, with nodules of ferruginous sandstone		3 0
11. Course of compact rock, occasionally calcareous	1 0 to	1 3
12. Compact rock, more ferruginous, and occasionally argillaceous		1 6
13. Ironstone beds—cellular ironstone, with ochreous, sandy, or green cores: towards the bottom the blocks are larger, and consist in the mass of green arenaceous material coated with iron-ore, as at Duston	10 0 to	12 0

The beds 2 to 6 are limestone of the Great Oolite, and are probably equivalent to the lower beds of the last section; but, lying near the surface instead of low down as in the limestone quarry, they have been altered by atmospheric action.

In the General Section, these beds would be referred to A; 7 and 8 would, I think, represent B; 9, with its plant-bed, C; 10, and perhaps 11, D; 12 may be considered perhaps debatable ground; but 13 would doubtless be included in E.

The fossils obtained in these ferruginous beds are all of kinds collected from the Duston Ironstone; but the zones of *Astarte elegans*, *corals*, and *plants*, seem here to be wanting.

The junction of the Ironstone beds with the Upper Lias is seen on the road-side at *e e*, well up on the hill between Blisworth and the railway station.

At Gayton, about a mile to the west, ironstone is also largely dug, the beds having very much of the character of, and yielding nearly the same fossils, as those of Blisworth,—very fine *Pygaster semisulcatus*, *Cidaris Fowleri* (confirmed by a fragmentary impression found by the late Dr. Berrill at the Northampton Asylum), very large casts of *Ceromya bajociana* and *Isocardia* (a new species), *Pleurotomaria armata*, *Astarte rhomboidalis*, Phil., and *Hyboclypus ovalis*, Wright, being noticeable. The overlying beds consist of the same series as in the other areas, but have been very much disturbed. The bottom bed of the limestone has yielded many large examples of *Rhynchonella concinna.*

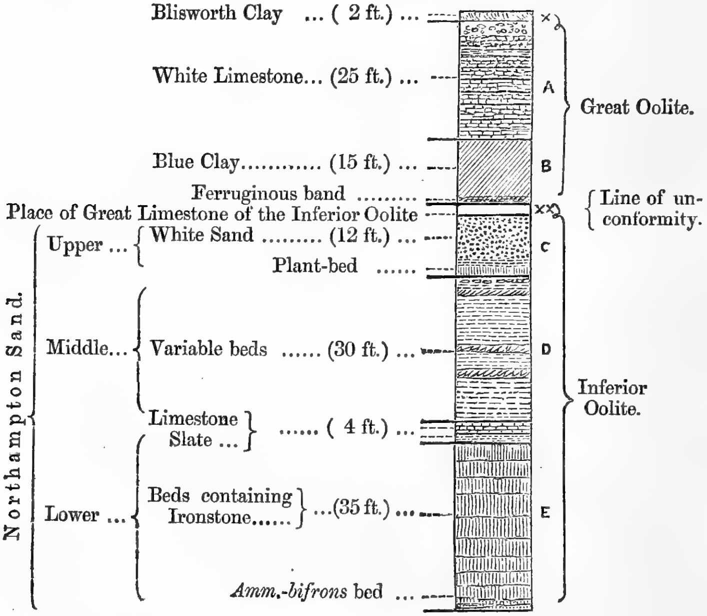
[Note.—Since the reading of this Memoir before the Society, I have been favoured by a visit from Dr. Lycett, who examined the majority of the sections which I have described, and who obliged me with the following written opinion as to the geological equivalency of the white-limestone beds of the district:—

"The Great-Oolite beds of Kingsthorpe, Duston, and Blisworth appear to me to correspond, both in their lithological character and included fossils, with the beds of Forest Marble to the eastward of Minchinhampton. The *Pholadomyæ*, the *Cardia*, the *Bullæ*, the *Corals* are identical; and the association of these forms in the

seams of marly clays, together with *Terebratula maxillata*, *T. intermedia*, and *Clypei*, adds greatly to the resemblance. I should be inclined, therefore, to assign them to the Forest Marble of East Gloucestershire and North Wiltshire.—J. Lycett."

Dr. Lycett has authorized me also to say that he considers the ironstone beds of the Northampton Sand equivalent to the ferruginous beds of Glaizedale and "the Doggers," Yorkshire, but that he has not found sufficient evidence for identifying any part of them with the "supra-Liassic" sands of the Cotswold district.—S. Sharp.]

Fig. 5.—*Diagram of General Section, showing the position of the Inferior Oolite Limestone and Divisions of Northampton Sand.*



Conclusion.

I have thus endeavoured, however imperfectly, to illustrate the Oolitic geology of a portion of the county of Northampton, and have left ample material for further inquiry.

Although the ground I have travelled over yields so much that is worthy of interest, an extension by a few miles of the field of investigation would bring other beds and other questions under review, which would amply repay for time and labour bestowed upon their examination.

By including the Blisworth area in my present Memoir, I have added a member to my General Section in the Great-Oolite Clay which overlies the limestone in the Blisworth quarry, and which, I believe, was first detected as distinct from the overlying Glacial Clay many years ago by Professor Morris.

Had not the limits necessarily of such a dissertation as this and of my own time forbidden, by extending my field some nine or ten miles to the north and north-east of Northampton I might have added to my General Section another member, second only (if second) in importance to, and perhaps as full of interest as, the Northampton Sand itself.

The great bed of limestone which marks the country about Stamford, and, traversing Rutland and West Lincolnshire, attains to its greatest development in the last, and which abounds in characteristic fossil forms of the Inferior Oolite, approaches Northampton on the north to a little south of Harrington, and on the north-east to the neighbourhood of Kettering, and is seen no more in the direction of Northampton or in the southern districts of the county.

During the last summer, I had the privilege of visiting, with Professor Ramsay, Mr. Etheridge, Mr. Judd, and Mr. Howell, a quarry in this limestone at Glendon Wood, near Kettering; whence, on that occasion, were obtained *Pygaster semisulcatus, Natica leckhamptonensis, Nerinæa cingenda, Serpula socialis, Pholadomya fidicula, Ceromya bajociana, Lima* (large new species occurring also in the ironstone), *Cardium cognatum, Trigonia hemisphærica, Gervillia acuta, Pinna cuneata,* and other fossils, sufficiently pointing to the Inferior Oolite as the formation to which this bed is to be assigned.

The position of this limestone, with reference to the Northampton Sand, appeared to be indicated by the neighbouring Glendon cutting of the Midland Railway in that sand, but had already been determined conclusively, as I believe, by Mr. Judd.

The place of this limestone of the Inferior Oolite, in reference to my General Section, is above C and below B, at XX, in the line of unconformity (see fig. 5)—thus marking the range upwards of the Inferior Oolite in this Midland district, establishing the line of demarcation between the Great Oolite and the Inferior Oolite in the neighbourhood of Northampton, and representing a period of marine as intervening between two periods of variable estuarine conditions.

I mention this fact incidentally only, as having but a secondary bearing upon the subject proper of my present Memoir. Should it ever be my lot to complete the scheme set forth in my Introduction, I shall go fully and carefully into an examination of this limestone, and into the question of its position with regard to higher beds.

In conclusion, I wish to acknowledge and to tender my thanks for the aid and information which I have derived from many geologists, naming especially Professor Morris (who first inoculated me with a love for geology, from whom I derived my initiatory knowledge, and, during many a pleasant excursion, much subsequent information), Professor Ramsay, Mr. Etheridge (who has kindly identified the majority of my local fossils), Mr. Judd (who has given me much assistance and original information), Dr. Lycett, Mr. H. Woodward, Mr. Carruthers, Dr. Hall, Mr. Davies (British Museum), and, lastly, but particularly, Dr. Wright, who has done me the great favour of writing an account of my new starfish, as a fitting accompaniment (as he kindly deems it) of this my maiden contribution to this Society.

Table of Fossils from Beds of the Great Oolite in the Neighbourhood of Northampton.

[NOTE.—The fossils in this Limestone consist for the most part of internal casts only, rendering it very difficult to determine with accuracy the species of some. It is not improbable, therefore, that instances of misdescription may occur in the following List.]

	Kingsthorpe.	Duston.	Blisworth.
LAMELLIBRANCHIATA (*Monomyaria*).			
Exogyra			
auriformis, *Goldf.*	*		
Gervillia			
islipensis, *Sow.*	*		
crassicosta, *Mor. & Lyc.*, var.	*		
Hinnites			
abjectus, *Phil.*	...	...	*
Lima			
cardiiformis, *Sow.*	...	*	*
duplicata, *Sow.*	*		
impressa, *Mor. & Lyc.*	*	...	*
Ostrea			
acuminata, *Sow.*	*		
costata, *Sow.*	*	*	*
gregaria, *Sow.*	*		
Marshii, *Sow.*	...	...	*
Sowerbyi, *Mor. & Lyc.*	*	*	*
subrugulosa, *Mor. & Lyc*	*	*	*
Pecten			
annulatus, *Sow.*	*	*	*
articulatus, *Schlot.*	*		
Griesbachii, *Lycett*	*	...	*
lens, *Sow.*	*	...	*
personatus, *Goldf.*	*		
rigidus, *Sow.*	...	...	*
symmetricus, *Morris*	*		
wollastonensis, *Lycett*	...	...	*
Pinna			
ampla, *Sow.*	*	...	*
cuneata, *Bean*	*	...	*
Perna			
rugosa, *Goldf.*	*	*	
Pteroperna			
costatula, *Deslongch.*	*	*	
plana, *Mor. & Lyc.*	*	*	*
LAMELLIBRANCHIATA (*Dimyaria*).			
Anatina			
plicatella, *Mor. & Lyc.*	*		
undulata, *Sow.*	*	*	
Astarte			
depressa, *Goldf.*	...	*	
elegans, *Sow.*	*		
Cardium			
Buckmani, *Mor. & Lyc*	*	*	

	Kingsthorpe.	Duston.	Blisworth.
Cardium			
cognatum, *Phil.*	*	...	*
globosum, *Bean*	*	*	
incertum, *Phil.*	*		
Stricklandi, *Mor. & Lyc.*	...	*	
subtrigonum, *Mor. & Lyc.*	...	*	*
Ceromya			
concentrica, *Sow.*	*	*	*
Symondsii, *Mor. & Lyc.*	*	*	*
undulata, *Mor. & Lyc.*	*		
sp.?	*	*	
Corbis			
bathonica, *Mor. & Lyc.*	*	*	*
Cucullæa			
cancellata, *Phil.*	...	...	*
concinna, *Phil.*	...	...	*
cucullata, *Goldf.*	*		
oblonga, *Sow.*	*		
Cypricardia			
bathonica, *D'Orb.*	*		
caudata, *Lyc.*	*	...	*
nuculiformis, *Rœmer*	*	*	*
rostrata, *Sow.*	*	*	*
sp.?	...	...	*
Cyprina			
Davidsoni, *Lycett*	*	*	*
islipensis, *Lycett*	*	*	
Loweana, *Mor. & Lyc.*	*	*	*
var. elongata?	*	*	*
trapeziformis, *Rœmer*	*	*	
Goniomya			
hemicostata, *Mor. & Lyc.*	...	...	*
Gresslya			
peregrina, *Phil.*	*	*	*
Homomya			
Vezelayi, *D'Arch.*	*	...	*
Isocardia			
nitida, *Phil.*	...	*	
tenera, *Sow.*	*	*	*
Limopsis			
oolitica, *D'Arch.*	...	*	
Lithodomus			
inclusus, *Phil.*	*	*	
Lucina			
Bellona, *D'Orb.*	*	*	
cardioides?, *D'Arch.*	*	*	*
despecta, *Phil.*	*		

	Kingsthorpe.	Duston.	Blisworth.
Macrodon			
hirsonensis, *D'Arch.*	*	*	
rugosa, *Lycett*	*		
Modiola			
cuneata, *Sow.*	*	*	*
imbricata, *Sow.*	*	*	*
Leckenbyi, *Mor. & Lyc.*	...	*	*
Lonsdalei, *Mor. & Lyc.*	*	*	*
Sowerbyana, *Bronn*	*	*	*
subreniformis, *Mor. & Lyc.*	*	*	*
tenuistriata, *Münst.*	*	*	
sp.?	...	*	
sp.?	...	...	*
Mytilus			
asper, *Sow.*	...	...	*
tumidus, *Mor. & Lyc.*	...	...	*
Myacites			
Beanii, *Mor. & Lyc.*	*	*	
calceiformis, *Phil.*	*	*	*
compressus, *Mor. & Lyc.*	*		
crassiusculus, *Mor. & Lyc.*	*	*	*
decurtatus, *Phil.*	...	...	*
gibbosus, *Sow.*	*		
scarburgensis, *Phil.*	...	*	*
securiformis, *Phil.*	*	*	
Terquemea, *Buv.*	*	*	*
tumidus, *Mor. & Lyc.*	*	...	*
unioniformis, *Mor. & Lyc.*	...	*	*
sp.?	*		
Neæra			
Ibbetsoni, *Morris*	*	*	
Nucula			
Menkei, *Rœmer*	*	*	*
Waltoni, *Mor. & Lyc.*	*	*	*
Pholadomya			
deltoidea, *Sow.*	*	*	*
Heraulti, *Ag.*	*	*	*
lyrata, *Sow.*	*	*	*
oblita, *Mor. & Lyc.*	*	*	*
ovalis?, *Ag.*	*	*	*
ovulum, *Ag.*	*	*	*
Phillipsii, *Morris*	*	*	*
Sæmanni, *Mor. & Lyc.*	*	*	*
socialis, *Mor. & Lyc.*	*	*	*
solitaria, *Mor. & Lyc.*	*	...	*
large species?	*		
sp.?	*	*	*
Pholas			
oolitica, *Mor. & Lyc.*	*		
Pholas			
pulchralis, *Bean*	*		
Quenstedtia			
lævigata, *Mor. & Lyc.*	*	*	*
oblita, *Phil.*	...	*	
Sphæra			
Madridi, *D'Arch.*	*	*	*
Tancredia			
angulata, *Lyc.*	*		
axiniformis, *Phil.*	*	*	*
planata, *Mor. & Lyc.*	...	...	*
truncata, *Lyc.*	...	*	
Thracia			
amygdaloides, *Lyc.*	*	...	*
curtansata, *Mor. & Lyc.*	...	*	
Trigonia			
compta?, *Lyc.*	*		
crucis, *Lycett* †	...	*	
Goldfussi, *Ag.*	*		
Moretoni, *Mor. & Lyc.*	*	*	*
sp.?	*	*	
Unicardium			
gibbosum?, *Mor. & Lyc.*	*	*	*
impressum, *Mor. & Lyc.*	*	*	
varicosum, *Sow.*	*	*	*
parvulum, *Mor. & Lyc.*	*	*	*
BRACHIOPODA.			
Rhynchonella			
concinna, *Sow.*	*	*	*
Terebratula			
digona, *Sow.*	*	...	*
globata?, *Sow.*	*		
intermedia, *Sow.* ‡	*	*	*
maxillata, *Sow.*	*	*	*
obovata?, *Sow.*	*	...	*
GASTEROPODA.			
Alaria			
armata, *Mor. & Lyc.*	*		
trifida, *Phil.*	*		
Amberleya			
nodosa, *Mor. & Lyc.*	*		
Bulla			
undulata, *Bean*	*		
Chemnitzia			
hamptonensis?, *Mor. & Lyc.*	*		
Natica			
adducta, *Phil*	*		

† This is the same *Trigonia* as that figured in Wm. Smith's 'Strata identified by Organized Fossils,' part 4, 1817, Cornbrash Fossils, fig. 4.

‡ This *Terebratula* has been thus named by Dr. Lycett; Mr. Etheridge, however, believes that it is only a variation in growth of *T. maxillata*.

	Kingsthorpe.	Duston.	Blisworth.
Natica			
canaliculata, *Mor. & Lyc.*	*	*	
coronata, *Mor. & Lyc.*	*		
formosa, *Mor. & Lyc.*	*	*	
globosa, *Rœmer*	*		
grandis, *Goldf.*	*		
intermedia, *Mor. & Lyc.*	*		
Michelini, *D'Arch.*	*		
neritoidea, *Mor. & Lyc.*	*	*	
(Euspira) pyramidata, *Mor. & Lyc.*	*	*	*
(Euspira) Sharpei ?, *Mor. & Lyc.*	*		
texata, *Lyc.*	*	*	*
Verneuili, *D'Arch.*	*	*	
species ?	...	...	*
Nerita			
hemisphærica, *Rœmer*	...	*	*
Nerinæa			
funiculus, *Desl.*	*		
punctata ?, *Voltz.*	...	...	*
Stricklandi, *Mor. & Lyc.*	*	...	*
Voltzii, *Desl.*	*	...	*
Phasianella			
acutiuscula, *Mor. & Lyc.*	*		
Pleurotomaria			
armata ?, *Münst.*	*		
Trochotoma			
tabulata, *Mor. & Lyc.*	...	...	*
Trochus			
(near to) spiratus, *D'Arch.*	*		
monilitectus, *Phil.*	*		
CEPHALOPODA.			
Ammonites			
gracilis, *Buckm.* (large old and smooth examples)	*	...	*
sp. small	...	...	*
Belemnites			
Bessinus ?, *D'Orb.*	*		
Nautilus			
Baberi, *Mor. & Lyc.*	*	*	*
latidorsatus, *D'Orb.*	*	...	*
subtruncatus, *Mor. & Lyc.*	*	*	*
ARTICULATA.			
Serpula			
plicatilis, *Goldf.*	*	*	*
ECHINODERMATA.			
Acrosalenia			
hemicidaroides, *Wright*	*	...	*
pustulata, *Forbes*	*	...	*
spinosa, *Ag.*†	*	...	*

	Kingsthorpe.	Duston.	Blisworth.
Acrosalenia			
Wiltoni, *Wright*	...	...	*
Hemicidaris			
minor ?, *Ag.*	*		
Clypeus			
Mülleri, *Wright*	*	*	*
Plotii, *Klein*	*	*	*
Echinobrissus			
clunicularis, *Llhwyd*	*	*	*
Griesbachii, *Wright*	*	*	*
Woodwardii, *Wright*	*	*	*
Holectypus			
depressus, *Leske*	...	...	*
Pentacrinus			
sp. ?	*	...	*
sp. ?	...	...	*
ZOOPHYTA.			
Anabacia			
orbulites, *D'Orb.*	*		
Cladophyllia			
Babeana, *Edw. & Haime*	...	...	*
CRUSTACEA.			
Eryma			
sp. allied to elegans of *Opp.*	*		
" " " var.	*		
PISCES.			
Hybodus			
dorsalis, *Ag.*	*	*	*
Lepidotus			
sp. ? (jaw, teeth, and scales)	*		
Pholidophorus			
Flesheri, *Ag.*	...	...	*
Pycnodus			
Bucklandi, *Ag.*	*	...	*
Strophodus			
magnus, *Ag.*	*	...	*
subreticulatus, *Ag.*	*	...	*
REPTILIA.			
Ichthyosaurus ?	*	...	*
Teleosaurus			
sp. ?	*	...	
PLANTÆ.			
Carpolithes			
sp. ?	*		
Kaidacarpum			
ooliticum (gen. & sp. nov.), *Carruthers*‡	*		
Wood (almost jet)	*	...	*

† And from Tiffield, the adjoining parish to Blisworth.

‡ See figures and a full description of this remarkable fossil in the 'Geol. Mag.' April 1868.

Fossils from the Great Oolite Ferruginous Band.

	Kingsthorpe.	Duston.	Blisworth.
Cypricardia			
rostrata, *Sow.*	...	...	*
Modiola			
imbricata, *Sow.*	...	...	*
Pteroperna			
plana, *Mor. & Lyc.*	...	...	*
Ostrea			
Sowerbyi, *Mor. & Lyc.*	...	...	*
subrugulosa, *Mor. & Lyc.*	...	...	*
Natica			
(Euspira) pyramidata, *Mor. & Lyc.*	...	...	*
sp.	...	...	*

Table of Fossils from Beds of the Northampton Sand in the Neighbourhood of Northampton.

[Note.—As in the Great Oolite Limestone, so also in the Northampton Sand, a large proportion of the fossils consist only of internal casts, so that the same probability exists that there may be some instances of erroneous description.]

D signifies that the fossil was obtained from the Middle Division of the N. Sand.
L signifies that the fossil was obtained from the Limestone Bed of the N. Sand.
E signifies that the fossil was obtained from the Lower Division of the N. Sand.

	Kingsthorpe.	Northampton.	Duston "Old."	Duston Ironstone.	Blisworth & Gayton.
Lamellibranchiata (*Monomyaria*).					
Avicula Braamburiensis, *Sow.*, var.	...	...	E		
„ (allied to) complicata, *Buckm.*	...	...	...	E	E
„ inæquivalvis, *Sow.*	...	D			
„ Münsteri, *Goldf.*	...	...	...	E	
„ sp.?	... ...	D	D L		
Exogyra sp. nov.?	...	...	...	E	
Gervillia acuta, *Sow.*	... ...	D E	... ...	E	
„ Hartmanni, *Goldf.*	...	...	...	E	
„ lata, *Phil.*	...	E	...	E	
„ prælonga?, *Lyc.*	...	...	...	E	
„ tortuosa, *Phil.* sp.	...	...	...	E	E
Gryphæa subloba?, *Desch.*	...	E	...	E	
Hinnites abjectus, *Phil.*	D	D E	D L	E	E
„ „ large variety	...	...	...	E	
„ velatus, *Goldf.* sp.	... ...	D E	... ...	E	E
Inoceramus Fittoni, *Mor. & Lyc.*	...	...	D	E	
„ obliquus, *Mor. & Lyc.*	...	E	D	E	
Lima * (closely allied to) antiquata, *Sow.*	...	...	D L		
„ bellula, *Lyc. & Mor.*	... ...	D E	...	E	

* Many forms of this genus occur in these beds which it is impossible to dentify with certainty: they doubtless represent several new species.

	Kingsthorpe.	Northampton.	Duston "Old."	Duston Ironstone.	Blisworth & Gayton.
Lima cardiiformis, *Sow.*	... ...	D E	D E	E	E
„ deltoidea, nov. sp., *Etheridge, MS.*	...	E	...	E	E
„ duplicata, *Sow.*	D	D E	D L	E	E
„ dustoniensis, nov. sp., *Eth. MS.*	...	E	L	E	E
„ electra	...	...	...	E	
„ „ (with Polyzoon, sp.)	...	E			
„ grandis ?, *non Rœmer* „ gigantea ?, *non Sow.*	... ...	D E	L E	E	E
„ „ ? var.	...	...	...	E	E
„ impressa, *Mor. & Lyc.*	D	D E	D	E	E
„ interstincta, *Phil.*	...	D	...	E	
„ luciensis ?, *D'Orb.*	...	...	...	E	
„ pectiniformis, *Schloth.*	...	...	...	E	
„ Pontonis, *Lyc.*	D	D E	D L	E	E
„ punctata, *Sow.*	... ...	D E	D E	E	E
„ rigida ?, *Sow.*	D	D E	... ...	... ...	E
„ rudis, *Sow.*	...	...	...	E	
„ Sharpiana*, *Etheridge, MS.* (a new smooth sp.)	...	E	...	E	
„ sp. ? (rectangular)	... ...	D E	...	E	
Ostrea costata, *Sow.*	...	D	...	E	
„ gregaria, *Sow.*	D	D	D	E	
„ Marshii, *Sow.*	...	D	...	E	E
„ Meadii, *Sow.*	...	...	...	E	
„ subrugulosa, *Mor. & Lyc.*	...	...	D		
„ flabelloides, *Lam.*	...	...	...	E	
„ sp. ?	D	D E	L	E	E
Pecten arcuatus, *Sow.*	...	L	D ?		
„ articulatus, *Schlot.*	D	D E	D E	E	E
„ clathratus, *Rœmer*	... ...	D E	... D	E	E
„ demissus, *Phil.*	D	D E	E	E	E
„ lens, *Sow.*	D	D L	D	E	
„ liasianus, *Nyst* (corneus of *Goldf.* non *Sow.*)	...	E	...	E	E
„ personatus, *Ziet.*	D	E	E	E	E
„ small sp. ?	D				
Perna rugosa, *Goldf*	... ...	D E			
„ quadrata, *Phil.*	...	...	...	E	
Pteroperna costatula, *Deslongch.*	...	...	...	E	E
„ gibbosa, *Lyc.*	...	E	...	E	E
„ plana, *Mor. & Lyc.*	... ...	D E	... ...	E	E

* Mr. Etheridge, in this name, has kindly complimented the author of this Memoir.

	Kingsthorpe.	Northampton.	Duston "Old."	Duston Ironstone.	Blisworth & Gayton.
Pinna ampla, *Sow.*	...	D	...		
„ cuneata, *Phil.*	... ...	D E	E	E	E
Placunopsis jurensis, *Rœmer*	...	...	E	E	
„ socialis?, *Mor. & Lyc.*	...	D			
Plicatula tuberculosa, *Mor. & Lyc.*	...	...	...	E	
LAMELLIBRANCHIATA (*Dimyaria*).					
Arca minuta?, *Sow.*	...	E	...	E	
„ Prattii, *Mor. & Lyc.*	...	...	...	E	
Astarte depressa?, *Goldf.*	...	E			
„ elegans, *Sow.*	...	E	E	E	
„ minima, *Phil.*	...	E	...	E	
„ rhomboidalis, *Phil.*	...	E	...	E	E
Cardium Buckmani, *Mor. & Lyc.*	... ...	D	D E	E	E
„ cognatum, *Phil.*	...	E	D E	E	E
„ semicostatum, *Lyc.*	...	D			
„ (near to) Stricklandi, *Mor. & Lyc.*	...	E	...	E	
Ceromya bajociana, *D'Orb.*	...	D	E	E	E
„ concentrica, *Sow.*	...	...	D	E	E
„ similis?, *Lyc.*	...	...	E	E	E
„ sp.?	...	...	...	E	
Corbicella bathonica, *Mor. & Lyc.*	...	E	E	E	
Corbis (allied to) Lajoyei, *D'Arch.*	...	...	...	E	
Crassina ——?, *Phil.*	...	E	D	E	E
Cypricardia bathonica, *D'Orb.*	...	D E	...	E	E
„ acutangula, *D'Orb.*	...	...	...	E	
„ nuculiformis, *Rœmer*, sp.	...	E	...	E	
„ sp.?	...	E	D		
Cyprina trapeziformis, *Rœmer*	D				
Cucullæa cancellata, *Phil.*	...	E	E	E	E
„ cucullata, *Goldf.*	...	E	...	...	E
„ oblonga, *Sow.*	D	E	...	E	E
„ ornata, *Phil.*	...	...	E		
„ several sps. undetermined	...	...	...	E	E
Gresslya abducta, *Phil.*	...	...	...	E	E
„ latirostris, *Ag.*	...	...	...	E	
„ peregrina, *Mor. & Lyc.*	...	E	...	E	E
„ small var.?	...	...	...	E	
Homomya Vezelayi? *D'Arch.*	...	...	...	E	
Isocardia cordata, *Buckm.*	... ...	... E	D E	E	E
„ new species (large)	...	E	...	E	E
Lithodomus inclusus, *Phil.*	...	...	...	E	E
Lucina Bellona, *D'Orb.*	...	...	...	E	E
„ „ var. depressa?, *Mor. & Lyc.*	...	E			
„ crassa?, *Sow.*	...	E			
„ rotundata?, *Rœmer*	...	E			
Macrodon hirsonensis, *Mor. & Lyc.*	...	...	...	E	E
Modiola Binfieldi?, *Mor. & Lyc.*	...	E	...	E	E
„ imbricata, *Sow.*	...	D	...	E	
„ Lonsdalei, *Mor. & Lyc.*	...	E	...	E	

	Kingsthorpe.	Northampton.	Duston "Old."	Duston Ironstone.	Blisworth & Gayton.
Modiola Sowerbyana, *D'Orb.*	...	...	...	E	
„ subreniformis, *Mor. & Lyc.*	...	...	...	E	
„ small sp.?	...	E	D	E	
„ sp.?	...	...	...	E	
Myacites dilatatus, *Phil.* sp.	...	E	...	E	
„ unionoides	...	...	...	E	
„ sp.?	...	...	...	E	
Myoconcha crassa, *Sow.*	...	...	...	E	
Opis, sp.?	...	E	...	E	
Pholadomya ambigua, *Sow.*	...	...	...	E	
„ fidicula, *Sow.*	...	...	E	E	
„ fidicula? or new sp. (semi-acuticosta)?	...	E			
„ Heraulti, *Ag.* (Desboro') E					
„ large new species?	...	...	...	E	
Quenstedtia lævigata, *Mor. & Lyc.*	...	E	...	E	
„ oblita, *Phil.*	...	E	...	E	E
Tancredia angulata?, *Lycett*	...	...	...	...	E
„ axiniformis, *Phil.*	D	E	...	E	E
„ planata, *Mor. & Lyc.*	...	...	...	E	
Trigonia angulata?, *Sow.*	...	...	...	E	
„ compta, *Lyc.*	D	...	D	E	E
„ costata, *Park.*	D	D E	D	E	E
„ „ var. pullus, *Sow.*	...	E	...	E	
„ denticulata, *Ag.*	...	E	E	E	
„ duplicata, *Sow.*	...	D			
„ Goldfussi, *Ag.*	...	...	E	E	
„ impressa, *Sow.*	...	E	E	E	
„ Phillipsii, *Mor & Lyc.*	...	E	E	E	E
„ Sharpiana (new species), *Lycett*	...	E	E	E	
„ V-costata, *Lyc.*	...	E	...	E	E
„ sp.?	...	...	D	E	E
Unicardium gibbosum, *Mor. & Lyc.*	...	...	D	E	E
„ impressum, *Mor. & Lyc.*	...	...	...	E	E
„ parvulum, *Mor. & Lyc.*	...	E	E	E	E
„ varicosum?, *Sow.*	...	...	...	E	E
„ sp.?	...	E	D E		
BRACHIOPODA.					
Rhynchonella angulata, *Sow.*	...	D	D		
„ cynocephala, *Rich.**	...	E			
„ quadriplicata, *Ziet.*	...	E	...	E	
„ subdecorata, *Dav.*	...	E	E	E	
„ tetraëdra, *Sow.*†	...	E			
„ subtetraëdra, *Dav.*	...	E			
„ variabilis, *Schloth.*	D	D E			

* In the lower part of the bed, and at Brixworth, in the same relative position.

† *Vide* Davidson's Ool. Brach., pl. xviii. fig. 10. This form is also nearly allied to *R. subdecorata*, Dav. It is also found commonly in the "Ironstone" in other parts of the country.

	Kingsthorpe.	Northampton.	Duston "Old."	Duston Ironstone.	Blisworth & Gayton.
Rhynchonella variabilis, var. bidens, *Phil.*	...	E	E		
" " var. triplicata, *Phil.*		E			
Terebratula Buckmani, *Dav.*	...	...	...	E	
" impressa, *V. Buch.*	...	...	...	E	
" ovoides, *Sow.*	D	D E	... ...	E	E
" perovalis, *Sow.*	D	D E	E	E	E
" submaxillata, *Sow.*	...	E	...	E	
GASTEROPODA.					
Alaria armata, *Mor. & Lyc.*	...	...	...	E	
" trifida, *Phil.*	...	...	...	E	
Chemnitzia, minute sp.	...	...	...	...	E
" scarburgensis, *Mor. & Lyc.*	...	E	...	E	E
Cirrus acutus, *Sow.*	...	E	...	E	
" nodosus, *Sow.*	...	...	...	E	
Littorina punctura, *Bean*	...	...	...	E	E
Natica adducta, *Phil.*	...	...	...	E	
" leckhamptonensis, *Lyc.*	...	...	...	E	
" neritoidea, *Mor. & Lyc.*	...	...	...	E	
" Verneuili, *D'Arch.*	...	...	...	E	
" casts and impressions of several undetermined species	...	E	E	E	E
Nerinæa cingenda, *Bronn.*	...	E	E	E	E
" Dufrenoyi?, *D'Arch.* (small sp.)	...	E			
" sp.?	...	E			
Nerita hemisphærica?, *Ræm.*	...	...	...	E	
Patella inornata, *Mor. & Lyc.*	...	...	...	E	
" nana, *Sow.*	...	...	...	E	
" rugosa, *Sow.*	...	...	...	E	
Pleurotomaria Aglaia, *D'Orb.*, var.	...	...	...	E	
" armata, *Münst.*	...	E	...	E	E
" clathrata, *Goldf.*	...	...	E	E	E
" Marcousana, *D'Orb.* (var.)	...	E	...	E	
" ornata, *Defrance*	...	E	...	E	E
" pyramidata	...	...	...	E	
" sp.?	...	E	...	E	E
Trochotoma calix, *Phil.*	...	...	...	E	E
" obtusa, *Mor. & Lyc.*	...	...	...	E	
" tabulata, *Mor. & Lyc.*	...	...	...	E	
CEPHALOPODA.					
Ammonites bifrons, *Phil.*	...	E	...	E?	
" insignis, junior, *Schubler*	...	...	...	E	
" jurensis, *Ziet.*	...	...	...	E	
" Murchisonæ, *Sow.*	...	E	E	E	E
" " var. corrugatus, *Sow.*	...	E	...	E	
" niortensis, *D'Orb.*	...	E			
" opalinus, *Rein.*	...	E	E	E	E
" (keeled) sp., young of Murchisonæ?	...	...	E	E	
" (no keel), sp.?	...	...	E	E	
" (like) solaris, *Phil.*	...	...	E	E	
" large smooth species	...	...	...	E	

	Kingsthorpe.	Northampton.	Duston "Old."	Duston Ironstone.	Blisworth & Gayton.
Ammonites, sp.?	...	E	E	E	
Nautilus obesus, *Sow.*	...	E	E	E	
,, polygonalis, *Sow.*	...	...	...	E	
,, sinuatus, *Sow.*	...	...	E		
,, sp.?	...	E	E	E	
Belemnites acutus, *Miller*	...	E			
,, Bessinus, *D'Orb.*	...	D	D		
	...	...	L		
	...	E	E	E	
,, elongatus, *Miller*	...	E	...	E	
,, sp.?	...	E	L	E	
,, phragmacones	...	E	...	E	E
,, ditto, very large	...	...	...	E	
Articulata.					
Serpula, sp.	D	D	D	E	E
		E	E		
,, plicatilis, *Goldf.*	...	E	E	E	E
,, socialis, *Goldf.*	...	E	...	E	
Echinodermata.					
Acrosalenia Lycettii, *Wright*	D	...	...	E	
,, spinosa, *Ag.*	...	D			
Cidaris Fowleri, *Wright*	...	E	...	...	E
,, Wrightii, *Desor* (spine)	...	E			
Clypeus Hughii, *Ag.*	...	...	...	...	E
,, sp.?	...	...	...	...	E
Echinobrissus clunicularis, *Llhwyd.*	...	...	...	E	
Hyboclypus agariciformis, *Forbes*	E	E	...	E	E
,, ovalis, *Wright*	...	...	...	...	E
,, sp.	...	...	...	E	
Pygaster semisulcatus, *Phil.*	...	E	...	E	E
Stomechinus germinans, *Phil.*	...	...	...	E	
Stellaster Sharpii, *Wright*, nov. spec.*	...	...	...	E	
Pentacrinus, stem and branch joints	D	D	D	E	
		E	L		
Zoophyta.					
Cladophyllia, sp.?, or Rhabdophyllia Phillipsii, *Edw. & Haime*	E				
Isastræa Richardsoni, *M.-Edwards*	...	E	...	E	
,, sp.?	...	...	...	E	
Thamnastræa, sp.?	E	D	...	E	
		E	...		
Latomeandra Davidsoni, *M.-Edw.*	...	E	...	E	
Montlivaltia Wrightii?, *M.-Edw.*	...	...	E	E	E
Stylina solida?, *M'Coy*	...	...	...	E	
Coral, sp.?	E				
Amorphozoa.					
Spongia, sp.?	...	...	...	...	E

* See Descriptive Note by Dr. Thomas Wright, F.R.S.E., F.G.S., &c., appended to this Memoir. This remarkable fossil will be figured in a forthcoming volume of the Palæontographical Society's Monographs.

	Kingsthorpe.	Northampton.	Duston "Old."	Duston Ironstone.	Blisworth & Gayton.
BRYOZOA.					
Several sp.?	... ...	D E	... ...	E	E
CRUSTACEA.					
Genus? species?	D				
Carapace of a Crab?* (resembling Atergatis Boscii)	...	...	...	E	
REPTILIA.					
Megalosaurus, sp.? (tooth)	...	...	L		
Teleosaurus, sp.? (scute)	...	...	...	E	
PLANTÆ.					
Impressions of bracts of cone?	...	...	...	E	
„ of flag-like leaves with seeds	...	...	...	E	
„ do. larger sp.	...	...	...	E	
„ of leaf-like fern-frond showing venation and sori?	...	...	...	E	
„ of leaf-like forms (horizontal)†	C	C			
Vertical perforations (Equisetites?)	C	C	C		
Wood	... ...	D E	D L E	E	

[NOTE.—Besides the fossils enumerated in the foregoing Table, there are not a few others, which, consisting of internal casts only, it is impossible either to identify or describe. Some of these, there is every reason to suppose, represent new species, and one or two possibly new genera; and such I reserve for future examination and comparison.—S. S.]

NOTES *on a* NEW SPECIES *of* STARFISH *from the* IRONSTONE BEDS *of the* INFERIOR OOLITE *of Northampton.* By DR. THOMAS WRIGHT, F.R.S.E. and G.S.

THE genus *Goniaster* was proposed by Prof. Agassiz, in his 'Prodrome,' to include Starfishes with a large pentagonal body, having the margin bordered by a series of wide, thick plates or tesseræ, superimposed in pairs, and which support spines, granules, &c. The upper and under surface of the disk is covered with small polygonal plates, set closely together like a mosaic, and fitted into this marginal framework: the free surface of the ossicles is smooth or covered with granulations. The ambulacral furrows are narrow, with two rows of pedal suckers therein; the vent opens near the dorsal surface, and the mouth-opening is slit-like and pentagonal.

Müller and Troschel, in their 'System der Asteriden,' suppressed the genus *Goniaster,* and instead thereof erected the genera *Astrogonium, Goniodiscus,* and *Stellaster.* The diagnostic characters of these groups were chiefly obtained from the structure of the mar-

* I am indebted to Mr. Henry Woodward, F.G.S. &c., of the British Museum, for this suggestion, offered as conjecture only.

† "C" indicates the Upper Division of the Northampton Sand.

ginal plates and appendages thereof, the figure and arrangement of the discal plates, and the form and development of the rays :—

1. *Astrogonium.* Marginal plates large and smooth towards the centre, their inner border encircled by granules.

2. *Goniodiscus.* Marginal plates having the entire upper surface covered with close-set granulations.

3. *Stellaster.* Marginal plates granulated, the ventral segment supporting a pendent spine, the rays elongated and tapering to a lanceolate extremity.

Many of these characters are absent in fossil *Goniasteridæ,* and are therefore valueless for palæontological purposes ; for this reason I have retained the genus *Goniaster* for the large pentagonal short-rayed forms, and that of *Stellaster* for those with a smaller disk and more elongated rays.

This division must be considered merely provisional until we become better acquainted with the comparative anatomy of extinct forms. The very fine fossil discovered by my friend Samuel Sharp, Esq., F.G.S., in the Ironstone beds of the Inferior Oolite near Northampton, and which forms the subject of this communication, belongs to the group *Stellaster,* in consequence of the smallness of the disk, and the length and development of the rays. The absence of pendent spines or any indication of their presence, warns us, however, to be cautious in drawing hasty conclusions as to the true generic position of this Starfish, seeing that the presence of this spine is considered to be diagnostic of living Stellasters. Whether this fossil ever possessed such a spine or not, the mould does not enable me to make any positive statement anent.

STELLASTER SHARPII, Wright.

Diagnosis.—Body pentagonal, sides arched, rays much elongated and tapering to a narrow extremity ; marginal plates thick, surface of the same finely granulated. Under surface of the disk covered with small close-set polygonal ossicles, having had apparently a very granular surface. The circumference of each ray surrounded by sixty pairs of marginal plates, which extend from the centre of the arch of one interradial space to the same point of the adjoining area. Ambulacral furrows wide, oral opening large.

Dimensions.—Diameter of the disk two inches from the centre of one areal arch to the same point on the opposite one; from ray-point to ray-point six inches, depth of the border at the centre of the arch three tenths of an inch.

Description.—This remarkable fossil is entirely a mould in Ironstone, none of the ossicles having been preserved; but the sharp impressions of their forms and sculpture impressed on the Ironstone reveal a tolerably correct idea of the anatomy of the plates.

The Starfish rests upon its upper surface, which is firmly imbedded in the matrix, so that the size, shape, and character of the dorsal ossicles still remain to be discovered. Those on the underside of the disk are nearly uniform in size, and are small, pentagonal and hexagonal.

The granulations on the surface of these small bones appear to

have been very large, whilst those on the marginal tesseræ were very small.

Affinities and differences.—This species resembles *Stellaster Berthandi*, from the 'Calcaire à Entroques' of Mâcon; it differs, however, from that form in being larger, and in having the interradial spaces more arched and the rays themselves much larger. But the marginal tesseræ and discal ossicles are very much alike. The mould, however, does not give the character of the granulations. It differs from *Goniaster obtusus*, Wr., from the Inferior Oolite of Crickley, in having longer and more lanceolate rays, and from *Goniaster hamptonensis*, Wr., from the great Oolite of Minchinhampton, in the greater width of its tesseræ and length of its rays.

STELLASTER BERTHANDI, Wright.

Diagnosis.—Body pentagonal, sides with arches much flattened; tesseræ thick and narrow, 36 to 40 pairs around the margin of one ray; under surface of the disk covered with small close-set equal-sized ossicles; ambulacral furrows wide; dorsal discal ossicles absent.

Description.—Since Mr. Sharp's specimen came into my hands for description, a plaster mould has been kindly communicated to me by Professor Berthand, of Mâcon, Saone-et-Loire, France. The original was collected from the 'Calcaire à Entroques,' Mâcon. I mention it here in connexion with *Stellaster Sharpii*, Wr., as showing that *Goniaster* was a type of the Asteridæ which prevailed during the first stage of the Jurassic period, as the three forms we now know are all specifically distinct, and belong to the Lower division of the Oolitic series.

DISCUSSION.

Mr. W. W. SMYTH commented on the great value of careful observations by local geologists, such as those brought before the Society by Mr. Sharp.

Mr. ETHERIDGE pointed out how a few years ago it was supposed that hardly a fossil was to be found in these Northampton Beds, and that they all belonged to the Great Oolite, and not to the Inferior, an error in which the Geological Survey had shared. The district was, however, now being resurveyed under the new light which had been thrown on the character of the rocks by the extensive quarrying which had taken place during the last few years, and which had afforded the opportunities so judiciously utilized by the author of the paper, who had placed the order of succession and the character of the Northampton Beds beyond dispute.

Prof. MORRIS had found a difficulty in reconciling the phenomena of the eastern and western Oolitic areas, but considered that the key of the arrangement was to be sought in the district between Northampton and Stamford.

Mr. SHARP briefly replied.

MARCH 23, 1870.

Frederick Antony Potter, Esq., B.Sc., Assoc. Royal School of Mines, Cromford Derbyshire, was elected a Fellow of the Society.

The following communications were read:—

1. *Notice of a* FRAGMENT *of a* REPTILIAN SKULL *from the* UPPER CRETACEOUS *of* GRÜNBACH. By Dr. EMANUEL BUNZEL.

[Communicated by Prof. Huxley, F.R.S. &c.]

(Abstract.)

THE bone described by the author was found by Prof. Suess in a coal-mine belonging to the Gosau formation at Grünbach, near Wiener Neustadt, from which Prof. Suess obtained numerous other bones also belonging to terrestrial reptiles.

The author stated that the reptilian character of the bone appeared at the first glance, as it shows a single condyle and a temporal fossa resembling that of a Crocodile; but it has some peculiarities, such as the convexity of the occiput and its gentle passage into the roof of the skull, without forming an angle as in other reptiles, the transverse ridge in the occipital region, the want of sutures between the bones, the globular form of the condyle, the horizontality of the base, the ascending direction of the clivus, and the large brain-cavity, which render it impossible to refer the animal to which this bone belonged to any recognized order of Reptiles.

The known skulls of Dinosaurians have a steep occiput, and exhibit more of the Lacertilian type; the fragment described by the author rather resembled that of a bird. The author consequently suggested the formation of a new order of fossil Reptiles, *Ornithocephala*, nearly allied to the *Ornithoscelida* of Prof. Huxley.

For the animal of which this fragment is the only known relic, the author proposed the generic name of *Struthiosaurus*.

---

2. *On the* PALÆONTOLOGY *of the* JUNCTION BEDS *of the* LOWER *and* MIDDLE LIAS *in* GLOUCESTERSHIRE. By RALPH TATE, Esq., Assoc. Lin. Soc., F.G.S., &c.

[PLATE XXVI.]

PREVIOUS to the writings of Messrs. Oppel and Wright on the classification of the various members of the Lias, that portion of the system which intervenes between the great limestone series of the Lower Lias below and the Marlstone above was referred to the Lower Lias; but these authors have drawn the line of demarcation between the Lower and Middle Lias through the mass of clays and shales which constitute the median portion of that system, the zone of *Ammonites raricostatus* being the uppermost member of the Lower Lias, and that of *Ammonites Jamesoni* the lowermost member of the Middle Lias. Now it has not been shown in any English publication that this separation harmonizes with the distribution of organic remains, and by the superficial reader the boundary-line may well be considered an arbitrary one; it will be my endeavour to establish the division of the Lower and Middle Lias as drawn by Oppel.

That the zone of *Ammonites capricornus* is intimately connected with the Marlstone there cannot be a doubt, and in the Yorkshire Lias it has for many years been grouped with it; but as the zones of *Ammonites Jamesoni* and *A. ibex*, in this country, have usually been regarded as imperfectly fossiliferous, the necessary data for comparison being absent, the position of these zones in the Middle Lias has, with some degree of reasonableness, been questioned, more especially because the lithological conditions of the upper zones of the Lower Lias (*sensu stricto*) are repeated in the zone of *Ammonites Jamesoni.*

Professor Ramsay, in his Anniversary Address to the Geological Society in 1864, leads us to infer that the divisional line between the Lower and Middle Lias is one of convenience; he shows by tables the number of species which pass upwards through the zones of the Lias, and in a *résumé* states that from the zone of *Ammonites raricostatus,* which forms the top of the Lower Lias, six species (eighteen species only are recorded), or about thirty-three per cent., pass upwards into the Middle Lias, whilst from the zone of *Ammonites Davœi* (here equivalent to the zones of *A. Jamesoni, A. ibex,* and *A. capricornus*) thirty-one species pass upwards, or very nearly thirty-eight per cent. The facts from which the above results have been obtained, if examined in detail, show that, as regards the species of *Ammonites,* their range is trenchant, but that common species of fossils graduate upwards from one division to another.

The number of species recorded in England from the several zones is given as follows:—zone of *A. oxynotus,* 6; *A. raricostatus,* 18; *A. Henleyi* and *A. Davœi,* 82; and considering the paucity of fossils from these zones bordering on the junction of the Middle and Lower Lias, it would be unphilosophical to lay too much stress upon their palæontological affinities and differences.

The scanty published information we possess relative to the organic remains of the lowermost zone of the Middle Lias is given by Oppel and Wright. The former author estimates the thickness of the zone of *Ammonites Jamesoni* in Robin Hood's Bay at 100 feet, and mentions the following fossil species:—*Ammonites Jamesoni, A. Taylori, Belemnites elongatus, Gryphæa obliqua, Pholadomya decorata,* and *Pinna folium.* He also notices the development of this zone at Charmouth, but gives no list of fossils; Mr. C. H. Day, however, has enumerated twenty-eight species of Mollusca from it. In the neighbourhood of Cheltenham, Dr. Oppel did not determine the occurrence of the zone of *Ammonites Jamesoni*; but Dr. Wright says* "in Gloucestershire the beds representing this zone are found only in some deep brick-pits near Leckhampton, whence I obtained fragments of *Ammonites Jamesoni* and *Gryphæa obliqua,* with *Rhynchonella rimosa.*"

Having during a series of years made a comparatively extensive collection of fossils from the "Belemnite beds" of the neighbourhood of Cheltenham, and being aided by several collectors and other sources of information, I am enabled to record from the zones of *Ammonites oxynotus* and *A. raricostatus* fifty species, and from the zone of *Ammonites Jamesoni* one hundred and sixteen species; these data

* Mon. Brit. Asteriadæ, Pal. Soc. p. 78 (1864).

go far to establish a broad line of demarcation between the Lower and Middle Lias.

The species enumerated in Table I. (p. 397) from the zones of *A. oxynotus* and *A. raricostatus* have occurred at Cheltenham, with the following exceptions, *Bel. excavatus* and *B. elegans* (Yorkshire), and *Montlivaltia mucronata*, *M. mammiformis*, and *M. radiata* (Fenny Compton). Those in Table II. (p. 398) have chiefly been obtained from near Cheltenham and at Aston Magna; the species recorded by Drs. Oppel and Wright, Mr. Day, and Prof. Phillips, from the zone of *Ammonites Jamesoni* in Yorkshire and Dorsetshire, are introduced.

At Cheltenham the zone of *Ammonites Jamesoni* is exposed in the clay-pits by the Leckhampton Road; it consists of a mass of blue shaly clay with a few thin bands of compacted shells. With the exception of *Ammonites ibex*, *A. Valdani*, *A. Henleyi*, the Belemnites, and *Inocerami*, the fossils are of small size, but most of the species enumerated occur in great numbers. The most abundant species are *Ammonites Valdani*, *Belemnites clavatus*, *B. umbilicatus*, *B. oxyconus*, *Dentalium minimum*, *Cerithium Slatteri*, *Chemnitzia liassica*, *C. Blainvillei*, *Turbo admirandus*, *Nucula cordata*, *Leda Galatea*, *Arca Stricklandi*, *Pentacrinus basaltiformis*, *Waldheimia numismalis*. The totality of the species correlates these beds with the Belemnite schist or Numismalis-beds of Hanover, Würtemberg, and France, the most complete list of fossils from which is that given by Schlönbach*. He records, eliminating synonyms, seventy-five species from this zone as developed in the north of Germany; of these, thirty-nine are peculiar, thirty-three pass to the zone above, six are found in the Lower Lias, and thirty-six occur in beds of the same horizon in England.

The species recorded from Aston Magna were obtained by Mr. Thomas Slatter in the railway-cutting near that village: the exact relation of the bed yielding the fossils was not ascertained; but that gentleman informs me that it is a soft blue clay underlying five or six feet of blue shaly clay, literally filled with broken pieces of *Spiriferina verrucosa* and *Belemnites*. The specific identity of the greater number of the fossils from this section with those from the zone of *Ammonites Jamesoni* at Cheltenham requires the Aston beds to be referred to that horizon.

From Table I. I deduce that of the fifty species recorded from the zones of *Ammonites raricostatus* and *A. oxynotus*, chiefly in the neighbourhood of Cheltenham, eight pass to the zone of *A. Jamesoni*, whilst thirteen occur in lower horizons, and twenty-nine are peculiar to these horizons in England.

Table II. records one hundred and fifteen species in the zone of *Ammonites Jamesoni*, sixty of which pass to higher zones, whilst eleven make their first appearance in the Lower Lias. Of the species common to the Lower and Middle Lias, five have been enumerated in the first table, so that there are fourteen species in common to the two formations.

But other species of the Lower Lias, not given in the above tables, reappear in higher stages of the Middle Lias. Such migrated species

* Deutsch. geol. Ges. vol. xv. 1863.

I.—*Table showing range of species of the zones of* Ammonites oxynotus *and* A. raricostatus.

	Lower beds of Lower Lias.	Zone of Am. oxynotus.	Zone of Am. raricostatus.	Passing to Middle Lias.
Ammonites armatus, *Sow.*	...	...	* !	*
—— bifer, *Quenst.*	...	* ! (2)		
—— Boblayei, *D'Orb.*	*	...	* !	
—— densinodus, *Quenst.*	...	...	* ! (1)	
—— Guibalianus, *D'Orb.*	...	* !		
—— lacunatus, *Buckman*	* !	?	* !	
—— muticus, *D'Orb.*	...	...	*	
—— nodulosus, *Buckm.*	...	...	* !	
—— oxynotus, *Quenst.*	...	* !	* (2)	
—— raricostatus, *Ziet.*	...	...	* !	
—— subplanicostatus, *Oppel*	...	...	* ! (1)	
Belemnites acutus, *Miller*	*	*	* !	
—— excavatus, *Phillips*	...	?	?	
—— elegans, *Simpson*	...	?	?	
Nautilus striatus, *Sow.*	*	* (1)	* (1)	
Actæonina Dewalqui, *Oppel*	...	* (2)		
Cerithium raricostati, *Tate*	...	...	* !	
Chemnitzia parva, *Wright*	...	...	* (1)	
Pleurotomaria raricostati, n. sp.	...	...	* !	
—— similis, *Sow.*	* !	* (1)	* !	
Tectaria imbricata, *Sow.*	...	...	? * (1)	* !
Patella Sabrina, n. sp.	...	...	* !	
Anomia pellucida, *Terquem*	*	* (1)		
Arca oxynoti, *Quenstedt*	...	* (1)		
Avicula longiarea, *Brown*	...	* (2)	* (2)	
Cardinia (Listeri, var.) hybrida, *Sow.*	* !	*	* !	
Cypricardia decorata, *Münst.*	*	* !		
Gryphæa obliquata, *Sow.*	*	?	* !	*
Hippopodium ponderosum, *Sow.*	...	...	* !	* !
Leda Romani, *Oppel*	* !	* (2)		
Mytilus minimus, *Sow.*	* !	* (2)		
Ostrea raricostati, *Wright*	...	...	* (1)	
Pecten æqualis, *Quenst.*	...	...	* !	
Plicatula ventricosa, *Münst.*	...	* (2)	?	
Pleuromya oblonga, *Wright*	...	...	* (1)	
Lingula Davidsoni, *Oppel*	...	* (2)		
—— metensis, *Terquem*	* !	?	* !	
Rhynchonella oxynoti, *Quenst.*	...	* ! (2)		
—— variablis, *Schloth.*	?	?	* (1)	* !
Spiriferina Walcotti, *Sow.*	*	?	* !	
Waldheimia numismalis, *Schloth.*	? *	? *	* !	* !
Berenicea striata, *Haime*	*	...	* !	
Stomatopora antiqua, *Haime*	*	...	* !	
Acrosalenia minuta, *Buckm.*	...	...	* (1)	
Pentacrinus scalaris, *Goldf.*	*	?	* ! (2)	
Serpula subpentagona, *Tate*	...	...	* !	* !
Montlivaltia mammiformis, *Dunc.*	...	...	*	
—— mucronata, *Dunc.*	...	...	*	
—— radiata, *Dunc.*	...	...	*	
—— rugosa, *Dunc.*	...	...	* !	
	16	18	37	7

! Indicates that the author has collected or examined the species from the zone. (1) On the authority of Dr. Wright. (2) Of Dr. Oppel.

II.—*Table showing range of species of the zone of* Ammonites Jamesoni.

* Bugbrook, Northampton. † Farrington Gurney. A. Aston Magna. C. Cheltenham. D. Dorsetshire (Lyme Regis &c.). Y. Yorkshire (Robin Hood's Bay).

Locality.		Lower Lias.	Am. Jamesoni.	Passing to higher zones.
C.	Ammonites armatus, *Sow.*	*	*	
C.	—— brevispina, *Sow.*	...	*	*
A. D.	—— fimbriatus, *Sow.*	...	*	*
D.	—— furticarinatus, *Quenst.*	...	*	
C. D.	—— Henleyi, *Sow.*	...	*	*
C.	—— ibex	...	*	*
C. Y.	—— Jamesoni, *Sow.*	...	*	*
C. D.	—— laticostatus, *Sow.*	...	*	*
C. D.	—— Loscombi, *Sow.*	...	*	*
C.	—— Maugenesti, *D'Orb.*	...	*	*
D.	—— notidianus, *D'Orb.*	*	? *	
D.	—— pettos, *Quenst.*	...	*	
Y.	—— Taylori, *Sow.*	...	*	
C.	—— Valdani, *Röm.*	...	*	
C. D.	Belemnites acuarius, *Schloth.*	...	*	
C. D.	—— apicurvatus, *Bl.*	...	*	
C.	—— breviformis, *Ziet.*	...	*	*
D.	—— charmouthensis, *Mayer*	...	*	
D.	—— calcar, *Phillips*	*	*	
A. C. D.	—— clavatus, *Schloth.*	...	*	*
A.	—— compressus, *Sthal*	...	*	*
Y. C. D.	—— elongatus, *Sow.*	...	*	*
D.	—— junceus, *Phillips*	...	*	
D.	—— longissimus, *Miller*	...	*	*
D.	—— microstylis, *Phillips*	...	*	*
C.	—— Milleri, *Phillips*	...	*	*
D.	—— nitidus, *Phillips*	...	*	
C.	—— obesulus, *Mayer*	...	*	
C.	—— oxyconus, *Hehl*	...	*	
D.	—— paxillosus, *Schloth.*	...	*	*
D.	—— pumilis, *Mayer*	...	*	
D.	—— striolatus, *Phillips*	...	*	*
A. D.	—— umbilicatus	...	*	*
D.	Nautilus inornatus, *D'Orb*	...	*	*
D.	—— semistriatus, *D'Orb.*	...	*	*
D.	Xiphoteuthis elongata, *De la Beche*	...	*	
A. C.	Cerithium camertonense, *Moore*	...	*	*
C.	—— ibex, n. sp.	...	*	
A. C.	—— Slatteri, n. sp.	...	*	
C.	—— armatum, *Münst.*	...	*	
A. C.	Chemnitzia Blainvillei, *Münst.*	...	*	
A. C.	—— liassica, *Quenst.*	...	*	
C. D.	—— undulata, *Benz.*	..	*	
A. C.	—— sp.	...	*	
A. C.	Exelissa numismalis, *Tate*	...	*	
C.	Dentalium minimum, *Strickland*	...	*	
C.	—— elongatum, *Münst.*	...	*	*
C.	Phasianella paludinaria, *Münster*	...	*	
C. D.	Pleurotomaria (Cryptænia) expansa, *Sow.*	...	*	*
D.	Littorina biornata, n. sp.	...	*	
A. C.	Trochus Thetis, *Münster*	...	*	*
A. D.	Tectaria Gaudryana ?, *D'Orb.*	...	*	*
D.	—— imbricata, *Sow.*	*	*	*
A.	Tornatellina capricorni, n. sp.	...	*	*
A. C.	Turbo admirandus, n. sp.	...	*	
C.	—— cryptænioides, n. sp.	...	*	
A.	—— cyclostomoides, *Koch & Dk.*	...	*	*

Locality.		Lower Lias.	Am. Jamesoni.	Passing to higher zones.
D.	Straparolus Wrightianus, n. sp.	...	*	
D.	—— bellulus, n. sp.	...	*	
D.	—— aratus, n. sp.	...	*	
A.	Anatina numismalis, n. sp.	...	*	
A. C.	Arca Stricklandi, *Tate*	...	*	
A.	—— numismalis, n. sp.	...	*	
A. C.	Astarte amalthei, *Quenstedt*	...	*	*
C.	—— sp.	...	*	
C.	—— sp.	...	*	*
C.	Avicula novemcostæ, *Brown*	*	*	*
C.	—— sexcostata ?, *Röm.*	...	*	
C.	—— substriata, *Münst.*	...	*	*
C.	Cardinia crassissima, *Sow.*	...	*	*
C.	Cypricardia cucullata, *Goldf.*	...	*	*
C.	Cucullæa Muensteri, *Goldf.*	...	*	*
A.	Gervillia lævis, *Buckman*	...	*	*
A. C.	Isocardia cingulata, *Goldf.*	...	*	
C. D.	Inoceramus ventricosus, *Sow.*	...	*	*
C.	—— substriatus, *Goldf.*	...	*	
A. C.	Leda acuminata, *Goldf.*	...	*	*
A.	—— complanata, *Goldf.*	...	*	
C.	—— Galatea, *D'Orb.*	...	*	
A.	—— subovalis, *Münst.*	...	*	
A.	Limea acuticosta, *Goldf.*	...	*	*
C.	Lima Echo, *D'Orb.*	*?	*	*
A.	—— scabricula, n. sp.	...	*	
A. C. D.	Nucula cordata, *Goldf.*	...	*	
C.	—— ungulella, n. sp.	...	*	
C.	Opis carusensis, *D'Orb.*	...	*	
C.	Pecten liasinus, *Nyst*	...	*	
C.	—— acutiradiatus, *Goldf.*	...	*	*
C.	—— personatus, *Münst.*	...	*	*
D.	—— velatus, *Goldf.*	...	*	*
Y.	Pholadomya decorata, *Hartmn.*	...	*	
Y.	Pinna folium, *Young & Bird*	...	*	*
C.	Plicatula alternans, *Deslong.*	...	*	
A. C.	—— ? spinosa, *Sow.*	...	*	*
A.	Venus ? bombax, *Quenst.*	...	*	
C.	—— pumila ?, *Münst.*	...	*	
	Mytilus scalprum, *Sow.*	...	*	*
A.	—— numismalis, *Oppel*	...	*	*
A. C.	Ostrea cymbium, *Lamk.*	...	*	*
Y.	—— obliqua, *Sow.*	*	*	
C. D. ?	Discina Holdeni, *Tate*	*	*	*
A. C.	Rhynchonella variabilis, *Schloth.* (var. bidens)	*	*	*
A.	—— furcillata	...	*	*
C.	—— rimosa	...	*	*
A. C.	Spiriferina verrucosa, *Buch.*	...	*	*
*	Waldheimia Heyseana, *Dunk.*	...	*?	*
A.	—— indentata, *Sow.*	...	*	*
A. C. D.	—— numismalis, *Schloth.*	...	*	*
C.	—— subovoides, *Röm.*	...	*	*
†	—— Waterhousei, *Dav.*	...	*?	*
Y.	Plumaster ophiuroides, *Wright*	...	*	
A. C. D.	Pentacrinus basaltiformis, *Miller*	...	*	*
A.	Serpula etalensis, *Piette*	*	*	
A. C.	—— plicatilis, *Goldf.*	...	*	
A.	—— subpentagona, *Tate*	*	*	*
C.	—— tricristata, *Goldfuss*	...	*	
		10 v. 11	116 v. 114	60 v. 58

include *Avicula cygnipes, Waldheimia perforata, Cidaris Edwardsii,* and some others; but their number is not so great as is usually supposed. The tendency among palæontologists to name every smooth punctated *Lima, L. punctata,* every scalariform striato-nodulose *Pleurotomaria, P. similis,* or every planulate *Cryptænia, C. expansa,* leaves no doubt that two species are often included under one denomination and that the numbers in common between the Lower and Middle Lias are doubtless fewer than is generally stated. I find, in the majority of cases, that the species cited from the Lower and Middle Lias belong to sectional groups, the species composing which have a general resemblance one to the other, and the differential characters cannot always be recognized at a glance. Of the many examples of the genus *Cryptænia* from the Lower Lias that I have examined, not one is referable to *C. expansa,* which is quoted from that formation. It is possible that some species of the zone of *A. raricostatus* may have been mingled with those of the overlying stratum during the period of its deposition; the similarity of the included matrices prevents a determination of the source of such presumed derivative fossils.

It may reasonably be urged that as the faunula of the zone of *Ammonites Jamesoni* forms an integral part of the fauna of the Middle Lias, and that as the species belonging to the zones of *Ammonites raricostatus* and *A. oxynotus* present nearly as great affinity to those constituting the fauna of the Middle Lias as they do to those of the Lower Lias, the line of demarcation between the Middle and Lower Lias should be drawn between the zones of *Ammonites obtusus* and *A. oxynotus.* This arrangement would give a total of one hundred and sixty-four species for the united zone, seventy-eight peculiar, fourteen from lower horizons, and sixty passing to higher beds of the Middle Lias. But many of the species which, in the Gloucestershire area, are restricted to the zones of *Ammonites oxynotus* and *A. raricostatus,* are elsewhere associated with indubitable Lower Liassic species in strata which, though superior to the "*Bucklandi*-beds," do not admit of a division into zones of life; and it is not certain whether these strata, which may be designated as the Belemnite beds of the Lower Lias (or the zone of *Belemnites acutus*), represent the whole of the beds superior to the zone of *A. Bucklandi,* or whether only a portion of the upper series is present. Beds of this character occur in Shropshire, near Bath, at Ballintoy, Co. Antrim, in the east of France, &c.

It is not my present intention to discuss the palæontological affinities of the whole Lower Lias and Middle Lias, which I reserve till such time as the claims of the so-called recurrent species have been fully investigated; but so far as the distribution of species in the uppermost beds of the Lower Lias, and in the lowest horizon of the Middle Lias is concerned, there appears to be a palæontological unconformity between the Lower and Middle Lias as herein defined. If this be true, then the lithological conditions will justify me in suggesting a break in the stratigraphical succession. It is a received axiom that a change in lithological conditions is accompanied by

a change in the life aspects. And though this may be attributable to certain physical changes, it does not necessarily imply the advent of a new period, the change of deposit and life representing often different regions of depth; instances of such mutability are not wanting in the Lias. But in the case of the upper part of the Lower Lias the conditions of depth and of deposit are repeated in the lower part of the Middle Lias, accompanied by a total change in the fauna, and not a recurrence, as we should expect if there had been an uninterrupted continuance of the conditions by which these clays had been accumulated.

A second phenomenon that gives support to the views expressed above, is that of the numerical decrease of specific forms as we pass up through the several stages of the Lower Lias, the maximum of decadence being attained in the zones of *Ammonites oxynotus* and *A. raricostatus*, whilst from the zone of *Ammonites Jamesoni* the species increase in number.

A third phenomenon, but of minor importance, is that of the introduction of new genera on passing the upper limit of the Lower Lias. I would cite *Xiphoteuthis*, *Exelissa*, *Rotella*, *Opis*, *Isocardia*, *Gresslya*, *Megerlea*, *Waldheimia* (with a few exceptions), *Terebratulina*, *Acroura*, *Uraster*, *Tropidaster*, *Luidia*, *Plumaster*, and *Astropecten*. The absence of corals is also to be noted.

In conclusion, the fact of the similarity in the lithological features of the zones of *Ammonites raricostatus* and *Am. Jamesoni*, with a very large percentage of distinct species, and the fact that the former horizon contains a fauna representing a marked decadence of Lower-Liassic species, and the latter zone a fauna consisting, in the greater part, of Middle-Liassic species, determine the attachment of the one to the Lower Lias, and of the other to the Middle Lias; and show that the line of demarcation is not arbitrary, but is in accordance with a greater or less unconformity of specific forms, perhaps sufficiently great to warrant us in assuming a palæontological and stratigraphical unconformity between the two formations to which each zone respectively belongs.

Part II.—Descriptions of New Species.

A.—*From the upper part of the Lower Lias.*

Pleurotomaria raricostati, nov. spec. (Pl. XXVI. figs. 9 & 9*a*.)

Shell turbinated, broader than high; whorls subquadrate, with small nodulations upon their angles, crossed by four longitudinal slender raised lines; upper surface of penultimate whorl with about six encircling equidistant raised threads, decussated by closely set and anteriorly curved striæ; the fissural band on the upper third of the lower part of the penultimate whorl, above which there is one encircling thread and below four larger and several smaller and intermediate longitudinal threads, the whole crossed by curved lines of growth; base slightly convex, subimperforate.

Dimensions. Height 2 inches; breadth 2·25 inches; height of last whorl 0·9 inch.

The species has some general resemblance to *P. similis*, Sow., but differs in the relative dimensions, the position of the band, and in the details of its ornamentation.

Locality. Zone of *Ammonites raricostatus*, Bredon. (Coll. Geol. Soc. *sp. unicum.*)

Dentalium limatulum, nov. spec. (Pl. XXVI. fig. 1.)

Shell small, moderately thick, obtusely triangular, slightly curved, ornamented with numerous closely set, regular, slightly oblique, and acute costæ.

Dimension. Length 0·5 inch.

D. angulatum, Buckman, from the zones of *Ammonites margaritatus* and *A. ibex*, resembles *D. limatulum* in its ornamentation; but the shell is quadrangular in form, and between three and four times the length of the present species. *D. decoratum*, Münster, from the St.-Cassian beds is similarly ornamented, but the figure is quinquangular.

Locality. Zone of *Belemnites acutus*, Cloverly, Salop (*Sir R. Murchison*). (*Sp. unicum*; Coll. Geol. Soc.)

Patella Sabrina, nov. sp.

The Rev. P. B. Brodie has submitted to my inspection the cast of a large limpet, obtained by him in the superior clays of the Lower Lias in the vale of Gloucestershire. Imperfect as the materials at my command are, yet they indicate the occurrence of a hitherto undescribed species of *Patella* in the Lower Lias.

Shell very large, turbinate, conical; sides subconvex; apex obtuse, central; base entire, elliptical.

Dimensions. Height 1·12 inch; diameters of the base 2 and 2·5 inches.

Chemnitzia crassicosta, nov. spec. (Pl. XXVI. fig. 6.)

Shell turreted, elongated; whorls convex, about ten; suture deeply channelled; a slight keel winds round the lower half of each whorl; surface of last whorl ornamented by strong curved round ribs, about fifty in number, crossed by a few depressed longitudinal threads, which are more prominent on the base of the shell.

Dimension. Total length 0·45 inch.

Locality. Zone of *Belemnites acutus*, Cloverly, Salop (*Sir R. Murchison*). (Coll. Geol. Soc.)

Serpula subpentagona, Tate.

Serpula pentagona, Terquem and Piette, Lower Lias, East of France, p. 118, t. 14. f. 13 & 14, 1865 (non Goldfuss, 1837).

To avoid the dual employment of the specific name *pentagona*, I here propose that the species described by Terquem and Piette should be termed *S. subpentagona*. The two species are very different: in *S. pentagona* the median carina is bounded on each side by an elevated costa; in *S. subpentagona* the shell is regularly pentagonal.

It occurs in the zones of *Am. raricostatus*, Cheltenham; *Am. Jamesoni*, Aston (*Slatter*); and *Am. margaritatus*, Dumbleton!; and on the Continent it is quoted from the zone of *Am. Bucklandi*, Fleigneux.

B.—*From the lower zones of the Middle Lias.*

Turbo admirandus, nov. sp. (Pl. XXVI. fig. 10.)

Shell small, heliciform, a little broader than high; spire short, with an obtuse apex composed of four inflated whorls, the superior of which are angulated and ornamented above by curved plications, which extend a little over the keel, and are crossed by longitudinal costellæ, the remaining portion cancellated and nodulose; the last whorl slightly inflated and subangular; base radiately costulate; peristome entire, thickened, and channelled anteriorly; aperture circular; umbilicus of moderate size and round.

Dimensions. Length 0·23 inch; diameter 0·22 inch; height of last whorl 0·17 inch.

Localities. Zone of *Ammonites Jamesoni*: Cheltenham (*Tate, Buckman*); Aston Magna (*Slatter*); ? Campden (*Brodie*).

Trochus Thetis, Münster, Goldfuss, t. 179. f. 10*. (Pl. XXVI. fig. 4.)

Turbo heliciformis, Quenstedt, Jura, t. 19. f. 25*.

Shell small, conical, spire elevated; apex acute, composed of 4–5 flat whorls, separated by a channelled suture; last whorl biangulated; upper surface ornamented with about twenty-four thick nearly straight costæ, which terminate in a subspinous tubercle on the elevated upper carina. In some examples the transverse ribs are terminated superiorly and inferiorly by tubercles. From the tuberculated rim of the upper keel proceed fine closely set curved striæ, which are continued on to the base of the shell. Base nearly flat, with four concentric ribs; columella oblique, with a callous expansion over the umbilical fissure; aperture oblique.

Dimensions. Length and breadth 0·20 inch.

Affinity. *T. Thetis* is closely related by its ornamentation and figure to *T. Doris*, Münster, Goldfuss, t. 179. f. 9, from the Lias of Pretzfeld, placed by D'Orbigny in the Toarcien, but cited by Dumortier from the zone of *Ammonites angulatus* in the South of France; it differs from that species in its biangulated last whorl and in having two rows of tubercles and not three; other minute differences are observable.

Distribution. Zone of *Ammonites Jamesoni*: Cheltenham (*Tate, Buckman*); Aston Magna (*Slatter*). Zone of *Am. margaritatus*, Hechinger (*Quenstedt*); Amberg (*Goldfuss*); St. Bonnet, Rhone (*Dumortier*).

Exelissa numismalis, Tate, Annals and Mag. Nat. Hist. Dec. 1869. (Pl. XXVI. fig. 5.)

* Figures represent casts only.

Straparolus Wrightianus, nov. sp. (Pl. XXVI. fig. 23.)

Shell small, discoidal, plano-concave above, deeply but narrowly umbilicated below; whorls five, regularly rounded, slightly embracing, smooth.

The species is related to *S. minutus*, Schübler, from the "zone of *Ammonites opalinus*," but differs in its fewer and embracing whorls, giving it a more compact form, and in the absence of a keel.

Dimensions. Diameter 0·15 inch; height 0·1 inch.

Dedicated to my friend Dr. T. Wright, from whom I received the species, having been obtained by Mr. Brady in the residuum of washings for Foraminifera.

The species associated with *S. Wrightianus* are *S. bellulus*, nov. sp.; *S. aratus*, nov. sp.; *Littorina biornata*, nov. sp.; *Pecten acutiradiatus*; *Dentalium minimum*, Strickland; *Leda Galatea*, D'Orb; *Waldheimia numismalis*; a few Ammonites (*A. Loscombi*, juv., &c.), &c.

Locality. Near Lyme Regis (zone of *Am. Jamesoni*).

Straparolus bellulus, nov. sp. (Pl. XXVI. fig. 22.)

Shell small, discoidal, plano-concave above, deeply but narrowly umbilicated below; whorls five, regularly rounded, slightly embracing, marked by numerous longitudinal costulæ and crossed by faint strongly arched lines of growth.

Of about the same size as *S. Wrightianus*, but the last whorl is proportionally higher.

Straparolus aratus, nov. sp. (Pl. XXVI. fig. 21.)

Shell small, discoidal, plano-concave above, deeply but narrowly umbilicated below; whorls five, regularly rounded, slightly embracing, ornamented with numerous thick flexuous ribs, attenuated at the suture and on the margin of the umbilicus.

But for the asymmetrical form, the shell of this species might be mistaken for that of some varieties of *Ammonites Jamesoni*, notably *A. polymorphus interruptus*, Quenstedt.

Though the above species of *Straparolus* are closely allied by their external figures, yet the numerous specimens I have examined exhibit no gradation in their ornamentation from one species to the other, and consequently they should rank as distinct species.

Littorina biornata, nov. sp. (Pl. XXVI. fig. 17.)

Shell ovate, imperforate; spire elongated, acuminate; whorls eight, subinflated; anterior whorls with two strong acute encircling ribs, last three whorls ornamented with about eight decurrent thick costæ; aperture subovate, entire; columella straight, slightly effuse at the base; base subglobose, smooth.

Dimensions. Length 0·22 inch; diameter of last whorl 0·08 inch.

Locality. With *Straparolus Wrightianus* &c. near Lyme Regis, zone of *Ammonites Jamesoni* (very common).

Turbo cryptænioides, nov. sp.

Shell turbinated, depressed, much broader than high; spire acute;

whorls five, convex, flattened above; the suture is channelled with an abrupt margin around the upper whorls, and linear around the lower ones; surface ornamented with numerous incised longitudinal lines and closely set striæ of growth, visible by the aid of a lens; base flat; umbilicus moderately wide, exposing all the inner whorls.

The shell of this species has great resemblance to that of *Cryptœnia heliciniformis*, Deslong., but it has more whorls in proportion to its size, and the outer margin of the last whorl is regularly rounded and not subcarinated. The absence of a fissural band, however, removes it from that species. From *Turbo Marcousanus*, Dumortier, it differs in its much more depressed spire, and by its ornamentation.

Locality. "Zone of *Ammonites Jamesoni*," Leckhampton Road, Cheltenham.

CERITHIUM IBEX, nov. sp. (Pl. XXVI. fig. 8.)

Shell turreted; whorls ten in a length of $\frac{7}{10}$ inch, smooth or slightly wrinkled transversely, angulated and imbricating; upper suture bordered by a thick rounded encircling rib.

Dimensions. Length 0·6 inch; breadth of last whorl 0·2 inch.

C. ibex has the general outline of a *Turritella*; but the aperture of a specimen in Dr. Holl's collection justifies the generic position I have assigned to the species. It is most nearly related to *C. sidæ*, D'Orbigny, Prodr. i. p. 215, which is described in the following terms:—"lisse avec une légère saillie, dans le sens de l'enroulement, au tiers supérieur de chaque tour. Sinémurien, Augy-sur-Aubois (Cher)." An examination of the type specimen of *C. sidæ* enables me to add a character omitted by the describer, and which distinguishes it from *C. ibex*, that is, *an encircling rib below the carina*, whereas in *C. ibex* the encircling rib is above the carina and bounds the upper suture.

Locality. Zone of *Ammonites Jamesoni*, Cheltenham (*R. T.*). I have examined specimens collected near Cheltenham by Dr. Holl, and near Gloucester by Mr. J. Jones (coll. Gloucester Mus.).

TORNATELLA CAPRICORNI, nov. sp. (Pl. XXVI. fig. 18).

Shell elliptical, spire elongated, apex mamillated; whorls five, scalariform; shoulder of whorl forming a right angle, obtusely rimmed; last whorl slightly impressed below the upper angle, longitudinally striated, and marked with fine curved lines of growth; aperture oval, very acute behind and subangular in front; outer lip thin; columella with a longitudinal fold.

Length 0·55 inch; last whorl about $\frac{6}{10}$ the length of the shell.

Locality. Zone of *Ammonites Jamesoni*, Aston Magna (*T. Slatter*). Zone of *Am. capricornus*, Mickleton Tunnel (*G. E. Gavey*).

7. ACTÆONINA CANARIENSIS, nov. sp.

Shell elliptical, spire elongated; whorls four, scalariform; angle of suture obtuse, margined; surface of shell shining, marked by

faint lines of growth; aperture oval, subtruncated in front; outer lip thin; columella without a fold.

Length 0·27 inch; last whorl about $\frac{6}{10}$ the length of the shell.

Locality. Yellow Lias (zone of *Am. ibex*) Hewletts, Cheltenham.

CERITHIUM SLATTERI, nov. sp. (Pl. XXVI. fig. 7.)

Shell elongated, turreted, acute; whorls ten, subquadrate, separated by a broad and deep suture; ornamented by about twenty-five obliquely transverse ribs, which, where crossed by the four equidistant longitudinal costæ, are raised into large closely set nodulations; aperture orbicular; columella straight, outer lip slightly effuse.

The longitudinal ribs are sometimes three in number, and not unfrequently with a smaller intermediate rib.

Length 0·25 inch.

Locality. Zone of *Am. Jamesoni*: Aston (*T.S.*), Cheltenham (*R.T.*).

The species is dedicated to T. Slatter, Esq., whose collection of fossils from Aston Magna has materially increased the value of the present communication.

LIMA SCABRICULA, nov. sp. (Pl. XXVI. fig. 15.)

Shell convex, oblong-ovate, ornamented with about twelve large acute costæ, which are finely and closely transversely striated, and towards the front carry nodes; the sulci are occupied by three slender costellæ, the outer ones of which are crenately dentate; the median costella is lamelliform; hinge-line straight, beaks acute and distant; hinge-area narrow, elongated; ligamental pit circular, external; ears short with radiating nodulose ribs.

Dimensions. Length 0·515 inch; breadth 0·4 inch; thickness 0·35 inch; length of hinge-line 0·22 inch.

Affinities. L. scabricula has much the figure of some varieties of *Limea acuticosta, Lima hettangensis, L. pectinoides*, &c., but differs from all in combining the characteristic ornamentation of several of the duplicate *Limæ*, none of which, however, present the intermediate ribs as in this species.

Locality. Zone of *Ammonites Jamesoni*: Aston Magna (*Slatter*); Middle Lias (*Am. margaritatus*), Fontaine-étoupe-four, Caen (*Tesson*, Coll. Brit. Mus.)

ARCA NUMISMALIS, nov. sp. (Pl. XXVI. fig. 3.)

Shell small, oblong, inflated, inequilateral; anterior side short, subtruncate, posterior obliquely truncate; umbones large, subapproximate, incurved and directed forwards, medially impressed; surface with undulate concentric ribs, which are subacute and minutely granulated; apical portion of left valve with radiating costellæ, of the right with fine striations.

Dimensions. Length 0·315 inch; height 0·25 inch; diameter 0·2 inch; length of anterior side 0·13 in.

Locality. Zone of *Ammonites Jamesoni*, Aston Magna (*Slatter*).

ANATINA NUMISMALIS, nov. sp. (Pl. XXVI. fig. 13.)

Shell small, elliptic-elongate, subequilateral, and somewhat com-

pressed; anterior side rounded, posterior but little attenuated; ornamented by concentric acute folds and striæ.

Dimensions. Length 0·4 inch; height 0·12 inch; diameter 0·1 inch; length of anterior side 0·22 inch.

This species belongs to the group *Cercomya*, Agassiz, but differs from the two other Liassic species (*A. præcursor*, Quenstedt, and *A. Delia*, D'Orb, or *A. sinemuriensis*, Martin) by its form and plications.

Locality. *Ammonites-Jamesoni* zone, Aston Magna (*Slatter*).

INOCERAMUS INCURVATUS, nov. sp. (Pl. XXVI. figs. 2 & 2*a*.)

Shell subrhomboidal; hinge-line nearly straight; umbones submarginal, inflated and incurved; outer surface marked with concentric folds.

The figure of the fossil is not perfect, but the distinctive characters are the gibbosity of the umbonal region and the strongly incurved beaks.

Length of longitudinal axis $2\frac{3}{4}$ inches.

Locality. Zone of *Ammonites capricornus*, Cheltenham (*R. T.*).

ARCA STRICKLANDI, Tate.

Arca truncata, Buckman, Geol. Cheltenham, t. 5. f. 6, p. 26 (1845), non *Arca truncata*, G. B. Sowerby (1833), non *Arca truncata*, Reuss (1843).

Specific name to commemorate the palæontological labours of Mr. Hugh Strickland in the Lias of Gloucestershire.

Distribution. Zone of *Ammonites Jamesoni*, Cheltenham! Aston Magna (*Slatter*). Yellow Lias, Cheltenham (*Buckman*).

LEDA GRAPHICA, nov. sp. (Pl. XXVI. fig. 12.)

Shell elliptical, rounded and inflated in front, posteriorly rostrated, ornamented with fine and closely set concentric striæ, which form chevrons on the postmedial line.

Dimensions. Breadth 1 inch; length of anterior side 0·35 inch: height 0·35 inch; diameter 0·3 inch.

This species has the general form of *L. rostralis*, Lamk., and a few other Liassic species, but is distinguished from all, especially by its chevron-like ornamentation.

Locality. Zone of *Ammonites capricornus*, Mickleton Tunnel (*Gavey*). (Coll. Geol. Soc. and Geol. Surv. Mus.)

NUCULA UNGULELLA, nov. sp. (Pl. XXVI. fig. 11.)

Nucula variabilis, Quenstedt, Der Jura, t. xxiii. f. 28, p. 188 (1858), non Sow.; id. Dumortier, Dépôts Jurassiques, iii. p. 121, 1869.

Shell ovate, subtrigonal; umbones inflated, depressed, recurved, submarginal; a keel proceeds from the umbo to the antero-ventral margin, enclosing a subconcave area; anterior margin truncated, posterior elongated and slightly compressed; ventral margin curved; lunule deeply impressed; surface covered by distant strong lines of growth; hinge-line with ten serial anterior teeth and fifteen posterior.

Dimensions. Length 0·35 inch; breadth 0·25 inch; thickness 0·25 inch.

Geological position. Zone of *Ammonites Jamesoni*: Cheltenham (*R. T.*); zone of *Am. margaritatus*, Hinterweiler, Swabia (*Quenstedt*); zone of *Am. Davæi*, Bassin du Rhône (*Dumortier*).

Observations. Quenstedt has confounded two apparently distinct species with *N. variabilis*, Sow.,—the one under review, which is easily differentiated by its inflated form, narrow and flattish anterior area, and its deep lunule, and a second (tab. xiii. f. 43), which I refer with some doubt to *N. navis*, Piette. The *N. variabilis*, Phillips, is referable to *N. Hammeri*, Goldf. The three species that have thus been confounded with *N. variabilis* agree in their general configuration, but are readily to be distinguished from one another and from *N. variabilis*.

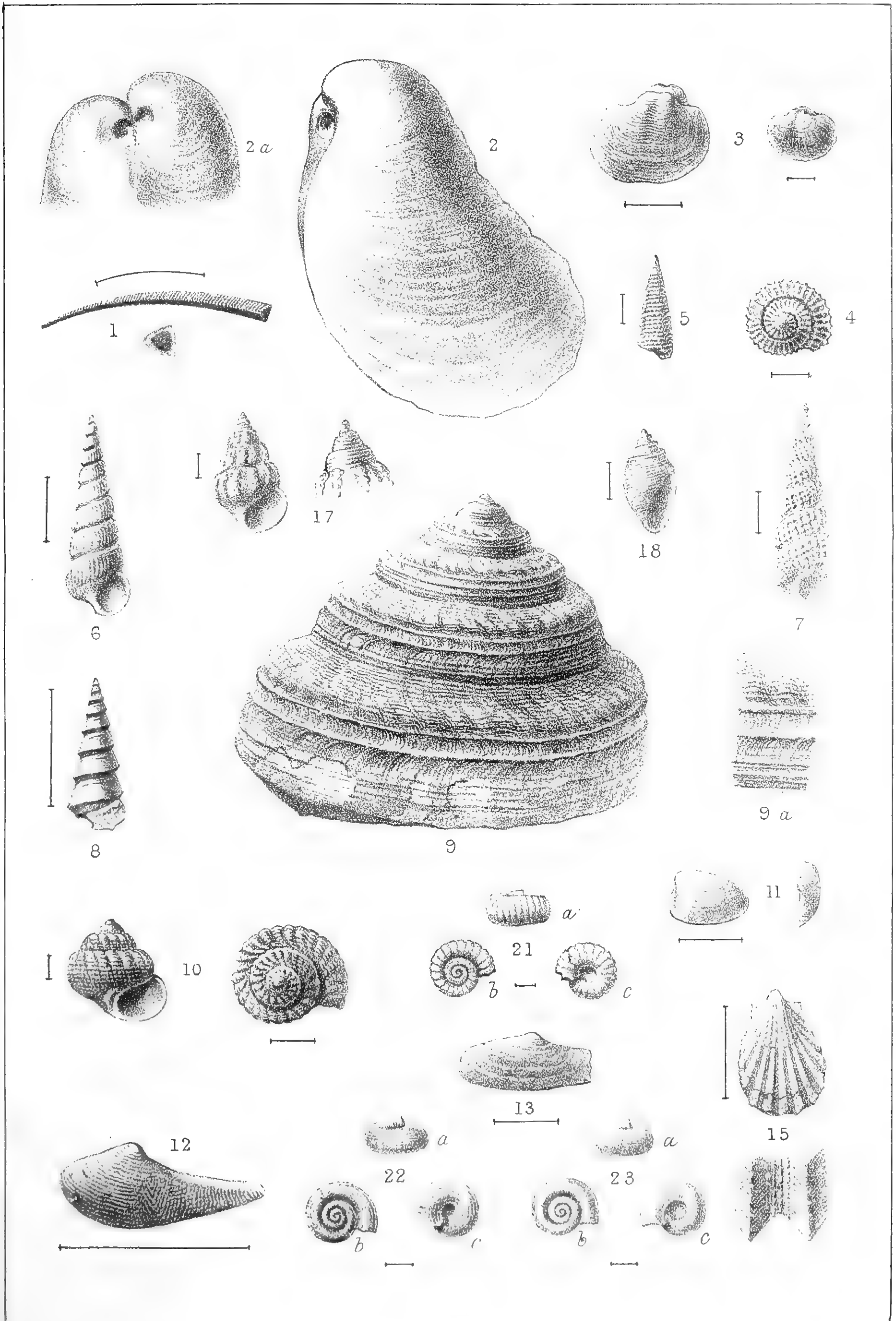
EXPLANATION OF PLATE XXVI.

Fig. 1. *Dentalium limatulum*, n. sp., enlarged.
2. *Inoceramus incurvatus*, n. sp., nat. size.
3. *Arca numismalis*, n. sp., enlarged.
4. *Trochus Thetis*, Münst.
5. *Exelissa numismalis*, Tate, enlarged.
6. *Chemnitzia crassicosta*, n. sp., enlarged.
7. *Cerithium Slatteri*, n. sp., enlarged.
8. —— *ibex*, n. sp., enlarged.
9. *Pleurotomaria raricostati*, n. sp., nat. size; and portion of test, enlarged.
10. *Turbo admirandus*, n. sp., enlarged.
11. *Nucula ungulella*, n. sp., enlarged.
12. *Leda graphica*, n. sp., nat. size.
13. *Anatina numismalis*, n. sp., enlarged.
15. *Lima scabricula*, n. sp., enlarged.
17. *Littorina biornata*, n. sp., enlarged.
18. *Tornatella capricorni*, n. sp., enlarged.
21. *Straparolus aratus*, n. sp., enlarged.
22. —— *bellulus*, n. sp., enlarged.
23. —— *Wrightianus*, n. sp., enlarged.

DISCUSSION.

Mr. BOYD DAWKINS had attempted to test these Liassic zones as a means of classification of the rocks in Somersetshire, and the result had been that he had been unable to accept them as fixing hard and fast lines of demarcation; for he had found three of the distinctive Ammonites together in one bed. On our present shores the change of one form of molluscan life for another seemed to take place in limited areas, and to be dependent on some slight variation of physical conditions rather than on any widely extended change. There was no stratigraphical unconformity between the Middle and Lower Lias in many parts of England, whatever might be the case in Gloucestershire.

Mr. TATE, in reply, gave an account of the manner in which he had arrived at his conclusions, and expressed his assent to the view that Ammonite-zones were only of value over limited areas, but considered that a triple division in the Lower and a dual division in the Middle Lias were well established on palæontological and lithological features. The break which he had pointed out was palæontological rather than stratigraphical, though the one might be inferred from the other.



W Purkiss del et lith.

M & N Hanhart imp.

LIASSIC SHELLS.

3. Geological Observations *on the* Waipara River, New Zealand.

By T. H. Cockburn Hood, Esq., F.G.S.

In 1859, whilst travelling in the Province of Canterbury, I discovered certain beds underlying the Waipara tertiaries, which I referred at the time to the Liassic series, and obtained from the bed of the River Waipara bones of an Enaliosaurian, which were placed in the British Museum, and which were recognized by Professor Owen as belonging to a new species of Plesiosaur, named by him *P. australis.*

Returning to the colony after ten years' absence, I found that a survey of that province had been completed by the Government Geologist, Dr. Haast, whilst the northern and southern portions of the Middle Island had been explored by that accurate and painstaking observer Dr. Hector. The Canterbury and Wellington museums afford interesting evidence of their careful labours: in the latter a collection of fossils from Triassic deposits of the Nelson Province is placed; and an excellent one adorns the former, from the Tertiary beds of the Waipara and other adjacent districts, which crop out here and there from beneath the vast accumulations of Postpliocene gravels.

With the exception of some small fragments of bones (ribs chiefly) of Reptilian origin, nothing appeared to have been found to assist in determining the species of the antipodean monsters. I determined therefore to make as thorough an exploration of the wild ravines of the Waipara as possible, with the assistance of my friend Mr. Innes, who is the proprietor of the Mount-Brown estate, under the base of which the river here runs, and who had taken much interest in collecting specimens.

A portion of this singularly broken country consists of a plain two miles and a half wide by about three miles in length, which appears at one time to have formed a lake (Fig. 1); the surface is now varied by a number of circular lagoons of some depth. The river and its affluents, which encircle this area, have cut their beds down through the lower Tertiary limestones and Septaria clays to the depth of many hundred feet; and the Upper Crag has been removed by denudation. The Cretaceous limestone, which affords an excellent building-material, is distinguished by a great abundance of a peculiar cup-shaped Bryozoon and remains of Echinoderms, and contains many Cetacean bones.

After some days spent in examining the deposits in the broad river-bed and that of the tributary flowing through the fantastically broken gorge shown in the sketch, we returned with a considerable quantity of bones, chiefly of *Plesiosaurus* (ribs, iliums, ischium, coracoid and digital bones), obtained from the intensely hard crystalline boulders (many weighing several tons), which I came to the conclusion were of an older date than the marly clay in which they are imbedded, having probably fallen from the cliffs on the shore of the Eocene sea, which, for some reason, was apparently destitute of life; the nucleus of all we succeeded in breaking was either a Saurian's bone, a *Gryphæa*, or a mass of calcareous spar. Nearly all contain great quantities of fucoids.

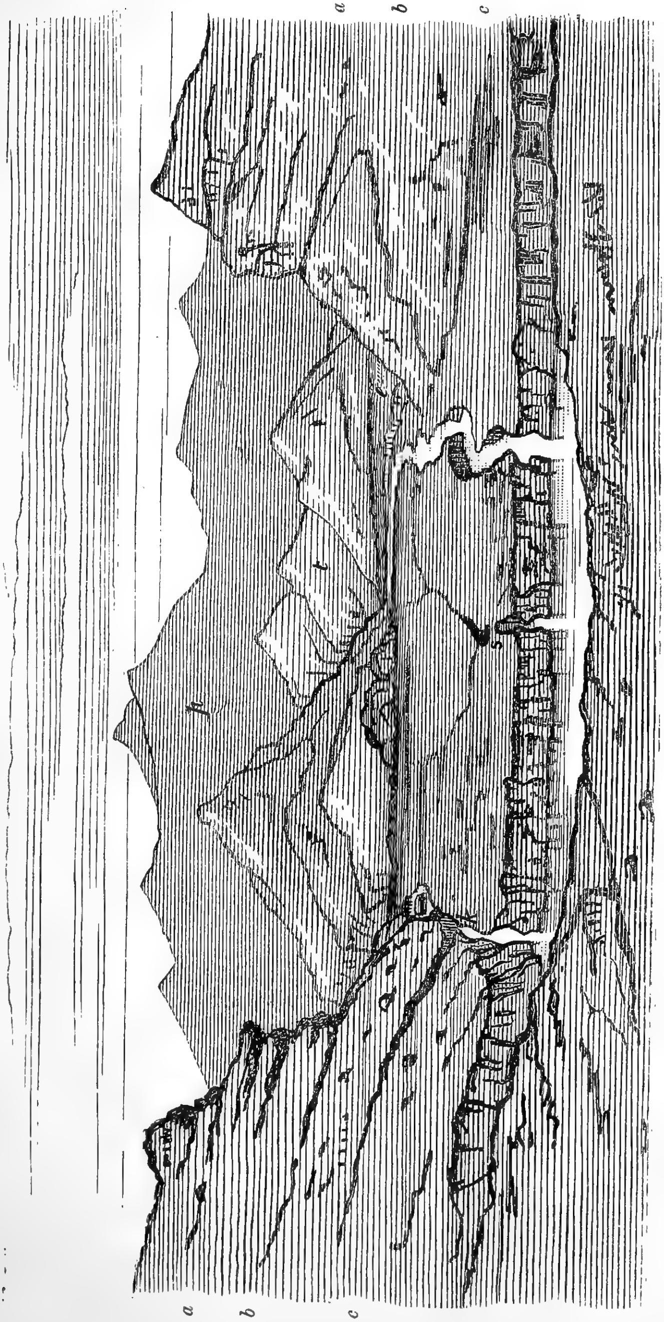
There was one deep dark defile which much tempted exploration; but the only possible means of access seemed to be far from agreeable. The mouth of the gorge was very narrow; two precipitous cliffs hung over a dark pool, at the base of a high slippery rock, over which the diminished summer stream fell in spray. We succeeded in creeping on our hands and knees along a narrow ledge, along the side of the cliff, and climbed the precipice; and the extraordinary scene alone would have rewarded us. Gigantic walls of rock ascended on either side 600 or 700 feet precipitously, from which threateningly projected the great indurated masses, circular, pear-shaped (some double, like huge hourglasses), ready apparently to fall at the slightest touch and add to the mass of fallen blocks, piled upon each other, which choked up the ravine to the depth of 50 feet and more, most of them containing fossil remains. In one lay displayed to view on the surface fifteen caudal vertebræ of a great *Plesiosaurus*: another had the cervical vertebræ and two forearms, with paddle-bones and digits, which we gazed at with longing eyes; but the size and hardness of the rocks rendered their extrication impracticable with such small tools as we had been able to bring. From the middle of another projected a small suspicious-looking bone, which might chance to prove a portion of what I so desired to obtain, the skull of the creature. Underneath the Septaria-clays lies a small seam of brown coal, having immediately above it a shell-bed some 18 inches in thickness, in which I found remains of fishes (palatal teeth of Rays &c.). I broke out with a hammer and wedge one large mass of oyster-shells, carbonized wood, and rolled quartz-pebbles cemented together, containing, along with several small lacertian teeth, two very perfect large vertebræ of procœlian character.

Returning on the next and several following days, we conveyed to the place large sledgehammers and crowbars, and brought additional arms to help us. Leaving a stonemason to cut out the vertebræ, Mr. Innes and I set to work at the large boulder; and when at last we managed with wedges to effect a fissure and get our heavy crowbar inserted, we had the infinite gratification of splitting it in half, and found that it divided along the surface of a magnificent skull in splendid preservation, with all the teeth complete, of a Teleosaurian 2 feet 8 inches in length from the point of the snout to the base of the cranium.

After a day's hard labour we succeeded in breaking it out of its crystalline matrix, in three portions, weighing about 100 lbs. each. On returning to where the stonemason was at work, it was not a little mortifying to find that he had smashed the specimen to pieces; however, it was a consolation that we had not intrusted the disengagement of the more valuable prizes to his hands. These we carried, step by step, to the edge of the precipice, and, lowering them with ropes, placed them where we were able to bring a packhorse up the river-bed. The collection obtained subsequently in this spot included several vertebræ of *Ichthyosaurus*, bones of the pelvis, also a femur and humerus of large dimensions.

From a rock by itself we also obtained portions of the skeleton of

Fig. 1.—*Bird's-eye view of Basin at the Gorge of the Waipara River, Canterbury, New Zealand.*



a. "Red Crag." *b.* Tertiary Limestone. *c.* Septaria-clays. *e.* Conglomerate, overlying Brown Coal, underlain by Ferruginous sand containing sulphur. *k.* Deep Gorge, with boulders containing Saurian bones. *t.* Secondary slates and sandstones. *p.* Cordillera.

a different Crocodilian, which had frequented the shores of the ancient estuary and, so far as my imperfect acquaintance with the subject enabled me to judge, appeared to belong to a species of *Teleosaurus* which had stood much higher off the ground than any hitherto figured. Considerable quantities of coprolites were imbedded in one of the boulders found in the river-bed; and in a gully some three or four miles to the north-west (which had been so deeply excavated by the great floods of late years, especially of 1866*, as scarcely to be recognized, any more than the upper part of the larger tributary, by one who had not visited the district for many years) valuable additions were made to the spoils. Here we were rewarded by finding a boulder with bones sticking out of it in all directions. It was intensely hard, however; and the fossils were in a very friable condition, and broke to pieces when the stone was struck, however carefully. We collected the fragments and covered them with gelatine in the shape of liquid glue; and the specimens (very splendid ones) proved quite perfect, and, when joined together, scarcely showed the fractures.

* The writer hopes to be able, in a future paper, to give exact details of the changes effected by the great storms which have within the last few years surprised the settlers in the Canterbury Province, and afforded most striking evidence of the power of running water to accomplish what, without such demonstration, most observers would probably deem it necessary to refer to the agency of ice. The great flood above referred to, descending suddenly without apparent adequate cause, was attributed in one place to the giving way of the barrier of some glacier-lake; in another district the astonished settlers, escaping from their submerged dwellings, imagined that a water-spout had burst over the lofty peaks of the inner ranges; but when the fact became known that the floods had extended throughout the country, from Nelson to Southland, it was plain that neither explanation sufficed. It is not difficult to account for such a débâcle in the Middle Island, subject to such storms as that which occurred in the winter of 1867, when the snow lay on the plains to the depth of 6 feet, and the drifts obliterated valleys of 500 feet in the lower ranges, so that in one instance a surveying party passed over a gorge of fully that depth, without being aware of its existence until the following summer. The accumulations of severe winters are exposed suddenly to the breath of the hot N.W. wind, which, rising up over the lower currents, passes across the intervening sea from Australia, and strikes upon the summits of the lofty Cordillera, and there rapidly melts the snows, and sweeps down upon the eastern plains with its dry scorching blasts, which, even in early spring raise the thermometer to 90° in the shade. Under such circumstances we may be prepared to witness even greater changes rapidly effected in the contour of the country, in which such remarkable memorials remain of the times when, under different cosmical influences, the climate was more rainy, and the glaciers (although still descending through noble forests to within a few hundred feet of the sea, upon a scale of almost unequalled grandeur) attained much vaster proportions, and other operations went on in proportionate magnitude. In Dr. Haast's excellent paper upon the formation of the Canterbury plains, the enormous deposits of gravel and sand are described that compose this great tract of country, which, although seemingly a dead level, slopes on an average 30 feet in the mile to the sea. In such a region one can understand great changes of the surface taking place also gradually and unobserved, under the eyes of the inhabitants. A curious evidence of this was afforded by the discovery of a silver ornament, at the depth of 50 feet, in digging a well at Christchurch, which gave rise to surmises as to the Peruvian origin of the aborigines, until the article was recognized by a lady as having been lost by her ten years before, when her husband pitched his tent near the spot.

They consisted of fourteen very large vertebræ of very slightly procœlian character (with processes in perfect preservation), bones of the pelvis and extremities, and a most singular one shaped like the ischium of a *Plesiosaurus* found in the other ravine, but much more angular. Here also a small hard concretionary boulder, as brilliant when fractured as fine granite, contained a very beautiful *Stenеopteris*.

The whole collection, being brought safely to Christchurch, was forwarded to England in the 'Matoaka,' which sailed in May last, but has not since been heard of.

Discussion.

Mr. Boyd Dawkins remarked on the presence of Crocodilia in New Zealand being proved by the procœlian vertebræ.

---

4. *On the* Discovery *of* Organic Remains *in the* Caribbean Series *of* Trinidad. By R. J. Lechmere Guppy, Esq., F.L.S., F.G.S., President of the Scientific Association of Trinidad, &c. &c.

[Abstract.]

The author described the formation called the "Caribbean Group" by the Government Geological Surveyors of the West Indies as forming a considerable portion of the littoral cordillera of Venezuela, and as extending eastward through the north of Trinidad to Tobago. It consists of gneiss, gneissose, talcose, and micaceous slates, and compact limestones. The metamorphic rocks of Guiana lately described by Mr. Ralph Tate (Quart. Journ. Geol. Soc. vol. xxv. p. 343) are regarded by him as of the same age as those of the littoral chain of Venezuela; and it is probable that the series occurs again in New Granada. Mr. David Forbes mentions the occurrence of gneissic and metamorphic strata on the Bolivian coast and in the desert of Atacama. According to M. Pissis, an extensive series of micaceous and gneissoid strata underlies the Silurian beds of Illimani in Bolivia; and Mr. Darwin alludes to strata of clay-slate &c. older than the Silurians of the Chilian Andes. The author considered that the Caribbean formation will be found to mark one of the "stable areas" insisted upon by Prof. Dana.

The northern range of mountains of Trinidad is composed entirely of rocks belonging to the Caribbean formation. The section from N.N.W. to S.S.E. from the sea, through the valleys of Diego Martin, Maraval, and St. Ann, shows the following succession of rocks in ascending order :—

1. Mica-slates, with quartzose sandstone; 2. Crystalline limestone; 3. Argillaceous slates, with hard sandstones, conglomerates, and thin beds and strings of calcareous matter; 4. Compact limestone, forming the Laventille hills bordering the plain of Caroni.

The total thickness of these rocks in Trinidad is stated by the author at upwards of 10,000 feet; and he is of opinion that the thick-

ness of the whole group is many times greater than this, a portion of the series in Venezuela being probably inferior in position to the rocks exposed in Trinidad. A high angle of inclination almost everywhere prevails, the general range of dip being from 30° to the vertical.

After noticing the difficulty which has hitherto existed in determining the age of the Caribbean formation, from the want of fossil evidence, the author stated that he has found undoubted traces of the existence of organisms during the deposition of these rocks. In the uppermost compact dark-blue limestone (No. 4) obscure fossils occur. In the clay-slates and quartz-rocks (No. 3) underlying this limestone there are strings and bands of calcareous matter which sometimes contain fossils. In a portion of one of these strings found by the author about 3 feet below the surface in the decomposed mica-slate forming the soil of one of the valleys, he detected a structure which he regards as of animal origin, and as probably most nearly related to *Eozoon*. He was unable to detect any traces of tubulation in it, but suggests that this character may have been obliterated, as in the Tudor specimen (Quart. Journn. Geol. Soc. vol. xxiii. p. 257). The chambers are said by the author to be more elliptical than those of *Eozoon canadense*; and for this and other reasons he proposed to regard it as a new species, under the name of *Eozoon caribbæum*.

Associated with this supposed *Eozoon*, the author has found other remains. These include fragments of coral, some of which are stated to resemble *Favosites*, although no pores or tabulæ could be detected in them. These fragments are thought by the author to have belonged to a minute branching *Favosites*, which he proposes to name *F. fenestralis*. Plates and stems of Echinoderms are scattered through the rock. The author particularly described a specimen consisting of five ambulacral plates, with four pairs of pores, and another fragment showing portions of at least twenty ambulacral or pseudo-ambulacral plates, reminding one of those of the Devonian *Eleacrinus*.

The author has found that the bands of calcareous matter interstratified among the slates are seldom devoid of organic remains, except when they are very highly metamorphic. In a finely laminated limestone he found great abundance of obscure fossils, many of which appeared to be remains of Cystidea, whilst others resembled annelid-tubes, like *Salterella*.

The author suggested that the function of *Eozoon* in pre-Cambrian times was analogous to that of corals at subsequent periods. He considered that there is the highest probability that the Caribbean series will ultimately prove to be pre-Silurian.

Discussion.

Dr. Carpenter, from the slight examination he had been able to make of the fossils, was unwilling to speak decidedly about them. There was, however, no doubt of numerous organic remains occurring in the rocks, and among them serpuline shells and echinoderms.

As to the supposed *Eozoon*, he had not been able to recognize any of the characteristics of that fossil; and by treating the Trinidad specimens with acid, he found no traces of structure left, and yet there had not been sufficient metamorphism to destroy other organisms. In some dredgings from the Ægean Sea he had found fragments of echinoderms and other organisms, in which a siliceous deposit had replaced the original sarcode in the same manner as had occurred in the Canadian *Eozoon*, thus proving the possibility of this form of substitution, which had been warmly contested.

Mr. Tate offered some suggestions as to the age of these beds, which were certainly older than Neocomian. The Californian gold-bearing beds appear to be Jurassic. Similar beds occurred in New Mexico, Guatemala, and were observed by him in Nicaragua and Costa Rica. These present lithological and mineralogical affinities to the Venezuelan and Trinitatian metamorphic series, and were conjectured to be of the same age.

---

5. *On the Fall of an* Aerolite *in* Fezzan. By M. Coumbary.

(Communicated by R. H. Scott, Esq., M.A., F.G.S.)

[Abstract.]

The object of this communication was to describe the fall of an aërolite or bolide, which took place on the 25th December, 1869, at Mourzouk, in Fezzan (lat. 26° N., long. 12° E. of Paris), in the presence of a group of Arabs. The bolide is described as a globe of fire nearly a metre in diameter, which, on falling, exploded with a sound resembling pistol-shots and a strong odour.

It is further stated that the whole or portions of the bolide will be forwarded—and that, according to information given, the poignards, sabres, and lances of the principal people of Waddai are constructed of meteoric iron, much of which has fallen in that district.

April 13th, 1870.

S. W. North, Esq., of Castlegate, York, was elected a Fellow of the Society.

The following communications were read:—

1. A letter from Dr. Gerard Krefft, dated Sydney, 29th January, 1869, accompanying a model of the left lower incisor of *Thylacoleo carnifex*, Owen, as restored by the author, and a cast of the original fragment which enabled the model to be made. Dr. Krefft referred as follows to the fossil remains of Herbivorous Marsupials in the Museum at Sydney:—

"There is a very fine series of fossil remains in the Australian-Museum collection, and very many of the specimens yet undetermined.

"Besides a large number of Wombats (*Phascolomys*) the existence of very Wombat-like Kangaroos, or rather Wallabies (*Halmaturi*), is proved by fossil remains of these animals. In fact the whole tribe was different from those of the present day, on account of the shortness of their extremities; the skull and lower jaw also differed considerably; and in the catalogue which I am preparing of these remains I have divided the Kangaroos into three distinct groups:—

"1. *Macropus*, with dentition as the present Kangaroos, whereof *Macropus major* is the type. Premolar soon lost.

"2. *Halmaturus*, represented by the smaller Kangaroos, known as "Wallabies." Head rather shorter than in the true Kangaroos. Premolar permanent.

"3. This group comprises all the gigantic species which have been referred to *Macropus*, but which in reality are gigantic *Halmaturi*, with very strongly developed premolars, resembling those of the genus *Bettongia*. But as there are two very distinct kinds of premolars developed, I have subdivided the *Halmaturi* again:—

"*a.* Into such as have long, narrow, and compressed premolars, moderately elongate heads, and the rami of the lower jaw but slightly anchylosed; and

"*b.* Into the Wombat-like Wallabies, with short heads, strongly anchylosed lower jaws (immovable jaws, in fact), incisors without cutting-edge. (The present Kangaroos and Wallabies have the rami only slightly anchylosed, and use the teeth like scissor-blades for cutting the grass.) The premolar tooth in this group is very compact, rounded, molar-like, and approaches in shape the same tooth in *Diprotodon* or *Nototherium*.

Discussion.

Prof. Owen remarked upon the importance of the researches made by Dr. Krefft and Prof. Thomson in the caves of Wellington Valley. No traces of man had been found. The numerous remains of Mammals, especially the Herbivorous species, had doubtless been carried into the caves by *Thylacoleo*.

Prof. Busk inquired on what grounds Prof. Owen decided that the teeth of *Thylacoleo*, of which casts were exhibited, were Carnivorous.

Prof. Owen indicated the remarkable compression of the tooth and the absence of the spatulate form proper to the Kangaroos, also its association with a large "carnassial" and small "tubercular" tooth, as characteristic of *Thylacoleo* and indicative of carnivorous habits.

Mr. W. Boyd Dawkins stated that *Thylacoleo* was most closely allied to *Plagiaulax*, which was probably a true Herbivore. He indicated the importance of the question, as, if *Thylacoleo* were a Carnivore, *Plagiaulax* would be one also.

Prof. Owen remarked that *Plagiaulax* was also a Carnivore. The premolars resembled the small tubercular molars of the Hyænas,

Felidæ, &c. The anterior tooth, associated with carnassial teeth and the small tubercular tooth, was compressed and sharp-pointed. The low condyle forming part of the angle of the jaw, was such as occurs in *Thylacinus*, not as in *Cheiromys*.

Dr. Duncan remarked that it is by no means necessary that all Carnivorous Mammals should be formed upon the same type, and that he did not see why there should not be a carnivorous form of the Kangaroo type.

The Chairman said that the settlement of these questions must now be postponed until we obtain further materials. He mentioned the discovery by Dr. Krefft, in the interior of Australia, of a species of fish resembling *Lepidosiren*, and possessing singular affinities to some of the Devonian fishes.

---

2. *On* Fossil Remains *of* Mammals *found in* China.

By Professor Owen, F.R.S., F.G.S.

[Plates XXVII.–XXIX.]

Since making known in 1858 the fact of a fossil tooth of an elephantine species having been obtained at Shanghai, China*, I have omitted no opportunity of acquiring further evidences of the extinct mammals of that part of the Asiatic continent; and I am now enabled to communicate characters of remains of several other mammalian genera, through the kindness of Robert Swinhoe, Esq., late H.M. Consul in the Island of Formosa, and to whom zoology is indebted for several interesting discoveries.

Before proceeding to the description of Mr. Swinhoe's specimens, I may premise a more complete description than has appeared of the first-mentioned fossil, of which outlines of the grinding-surface and inner and outer side views are appended, of the natural size (Pl. XXVII. figs. 1, 2, 3).

Stegodon sinensis, Ow.

The tooth in question is the second upper molar (*d* 3 of the type series) from the right side. Its crown, in a length of three inches, is divided into five transverse ridges, the proportions of which, as to height and basal breadth, with the ridged and wrinkled character of the enamel, suffice for its reference to a species of the group of Proboscidians discovered by Crawfurd in the Irrawadi Tertiaries of Ava, and described by Clift in the second volume of the second series of the Transactions of the Geological Society (p. 369, pls. 36–39, 1828). And here I beg leave to express my sense of the wise appreciation of the needs of the palæontologist by the Council of the Society in publishing figures of the type molars of those "Transitional Mastodons"† of the natural size.

In the present tooth the first or foremost ridge (Pl. XXVII. figs. 1

* By Mr. Lockhart, 'Report of the British Association for the year 1858,' "President's Address," p. lxxxvi.

† Odontography, p. 224, Section 228.

& 2, 1) is defined by a cleft on the outer side of the tooth, but not on the inner side, fig. 3; here the abraded surfaces of ridges 1 and 2 are blended by wear into a common hollow field of smooth dentine (fig. 1, *a*). There is a slight constriction near the part where the worn surface of the first ridge blends with that of the second; and this constriction, which may be detected in the succeeding ridges, I take to be a trace of that stronger one which more completely divides the transverse coronal ridge in the molars of better Mastodons into an inner and an outer part. A well marked tubercle (figs. 1 and 2, *f*) projects at the outer side of the base of the first ridge, 1, near the interspace between that and the second ridge. The second field of abrasion (ib. ib. 2) although it broadens inwards to the common hollow, shows, before losing its individuality, a similar indication of constriction, or reciprocal inbending of the enamel boundary. The same indication, though feeble, is obvious in the succeeding ridges (3, 4, 5, *a*), which, by the unequal working of the lower grinder, show a broader field of dentine as they pass inward. The third and fourth ridges, which are entire, show their slightly undulated course from the outer to the inner side, which is lower and more worn. The ridge at first inclines a little backward, then, at the indication of constriction, bends forward, and finally resumes the transverse course to the inner, lower and more worn side of the tooth.

Now this character is not shown in the *Mastodon elephantoides*, Clift, of which the antepenultimate upper molar (*m* 1) is figured, of the natural size, in plate 39. fig. 6, *loc. cit.*,—nor in the homologous tooth of the same species, also from Ava, figured (one-third natural size) as of *Elephas Cliftii*, in the 'Fauna Antiqua Sivalensis' of Falconer and Cautley, pl. 30. fig. 2.

From the general conformity of character of the transverse ridges in the last three molars (*m* 1, *m* 2, *m* 3) of this species, it is unlikely that so marked a difference of course and configuration of the ridges should exist in the second grinder, answering to *d* 3, of the same species.

Nevertheless in the number of ridges in a given tract of the grinding-surface, in their height and breadth of base, and in the absence of intervening cement, the conformity of the Chinese molar with the grinders of the *Mastodon elephantoides* is close. The enamel also shows the same vertical linear impressions and ridges, by which we may reckon that the summit (say, of the fourth ridge in the tooth here described), if it were unworn, might be cleft into from thirteen to fifteen small mamillæ.

This structure is well shown in the full-sized figure of the upper molar (*m* 1) of *Mastodon elephantoides*, Clift (in plate 39. fig. 6, Trans. Geol. Soc. vol. ii. second series).

In a tooth of an allied species from the Siwalik tertiaries, homologous with the specimen under description, figured in the 'Fauna Antiqua Sivalensis,' pl. 29. figs. 3, 3 *a*, as of *Elephas bombifrons*, but subsequently referred by Falconer to his *Elephas (Stegodon) insignis**,

* Palæontological Memoirs, vol. i. p. 459, in description of plate 29.

one may make out in the reduced figure (half natural size) the presence, but not the number, of marginal mamillæ on the fourth or penultimate ridge. But whilst this figure illustrates the degree of correspondence, it serves at the same time to show the specific degree of difference between the second upper milk-molar of *Mastodon (Stegodon) sinensis* and *Mastodon elephantoides*, Clt., or *Stegodon insignis*, Fr.

The original of Falconer's figure being in the British Museum, yields the following admeasurements, giving the difference in size and proportions between:—

	Steg. sinensis.		*Steg. insignis.*	
	in.	lines.	in.	lines.
Length of crown	2	10	2	6
Greatest breadth of crown	2	0	2	$1\frac{1}{2}$

In *Stegodon sinensis* the deciduous tooth is longer (antero-posteriorly) in proportion to its breadth. The tubercle at the outer interspace between the first and second ridges is larger and situated more immediately upon the interspace, closing it externally. The transverse divisions increase in breadth from the first to the fourth, the last being narrower, though not to the same degree as in *Steg. insignis*; neither do the ridges increase so regularly to the fourth in the Ava and Siwalik species as in *Steg. sinensis*. The ridges in *Steg. insignis* are loftier as well as narrower than in *Steg. sinensis*; the sculpturing is somewhat coarser; the fourth unworn ridge shows about twelve mamillæ. The fangs or roots of the tooth are not defined in the Siwalik tooth. In the Chinese one the fore part of the crown, divided externally into the two anterior ridges (Pl. I. fig. 2, 1 & 2), is supported by one fang deeply grooved on the side turned toward the second: this root is much larger, and supports all the remainder of the tooth; its base being entire, we are able to infer that only the hind part of the last coronal ridge (5) has been broken away, and that there could not be any added talon at that end of the tooth. The anterior vertical surface of the crown (ib. fig. A) shows a smooth concavity with the enamel worn through to the dentine by the pressure against the antecedent molar (*d* 2). The thick layer of cement which coats the dentine of the base of the tooth and its two divisions is well preserved, which leads me to doubt whether it could at any time have existed in the coronal clefts of the teeth of the present species.

The molars of *Elephas (Stegodon) insignis*, Fr., chiefly differ from those of *E. (St.) Cliftii*, Fr., in the much greater mass of laminate cement that fills up the valleys*. As this difference is to be added to those above described, it further opposes the reference of the Chinese proboscidian tooth to the *St. insignis*.

Of the *Elephas (Stegodon) Cliftii*, Fr., no tooth has yet been acquired homologous with the Chinese specimen. From the general analogy of retention of pattern of grinding-surface, notwithstanding the increase of size and number of coronal ridges as the molars recede in position, we may certainly infer, from there being no mark

* Falconer, 'Palæontological Memoirs,' 8vo, vol. ii. p. 85.

of a longitudinal line bisecting the tooth into an outer and an inner division*, and from the ridges "being a little convex in front and concave behind, determining a similar form to the valley between them"†, that the milk-tooth with sinuously disposed ridges and valleys cannot belong to that species.

I note, however, in the upper molars of the *Elephas* (*Stegodon*) *bombifrons*, Fr., a tendency to sinuosity in the transverse course of the ridges, and an indication of a median constriction in some of them, which comes nearer to the character of the Chinese tooth. Unfortunately the homologue of that tooth has not been obtained of the *E. bombifrons*. It is very significant of the tact of discerning differential characters so happily possessed by our late distinguished fellow labourer, that in the figures (5 and 6) which he has given of two fragments of large upper molars with the above characters somewhat more marked, in plate 29 *A* of the 'Fauna Antiqua Sivalensis,' illustrative of his *Elephas bombifrons*, he should have appended to his ascription of those fragments to that species a note of interrogation, and should have added in the posthumous account given in the 'Palæontological Memoirs' the following expression of mature and probably final opinion:—"Doubtful what figures 5 and 6 are" (vol. i. p. 460).

Now, after a close comparison of my Chinese deciduous molar with every specimen in the British Museum likely to elucidate its specific character (and most have been beautifully figured, though, unfortunately, with much reduction of size, in the master-work above quoted, 'Fauna Antiqua Sivalensis'), and with specimens and figures of specimens in other collections, there is none more likely to belong to the same species of *Elephas* or *Mastodon* or *Stegodon* than the fragment of upper molar from the Siwalik tertiaries, of the specific nature of which Falconer was doubtful. I conclude, therefore, that the best service to science will be to record the characters, with figures of the natural size, of the second upper grinder, *d* 3, right side, of the proboscidian from Shanghai, as of a *Stegodon sinensis*, to which, with probability, though not with certainty, the fragments of the large *Stegodon*, of a species to Falconer unknown, from the Siwalik tertiaries may also belong.

Howsoever this may prove, it is acceptable to find the results of comparisons converging and concurring in approximating the Chinese Proboscidian most nearly to those extinct forms which have laid their bones and teeth in localities geographically nearest to the grave of the *Stegodon sinensis*.

I have not deemed it expedient to slice a unique tooth for microscopical scrutiny; but there is no more appearance of cement in the coronal interspaces of the present Chinese fossil molar than in those of the more Mastodontal forms of Proboscidia. This, however, would not exclude the *Mastodon sinensis* from the section of Pro-

* Falconer, 'Palæontological Memoirs,' vol. i. p. 113.

† Ibid. p. 114. Both these characters are well shown in the upper (first true) molar of Clift's *Mastodon elephantoides* = *Stegodon Cliftii*, Fr., *loc. cit.* pl. 39. fig. 6.

boscidia indicated in my 'Odontography' as "transitional forms"*, since defined by Falconer under the generic name *Stegodon*†, of which he gives as one character, "the enamel is very thick, and the coronal interspaces, in most species, are filled up with an enormous quantity of cement"‡—an admission of exception which significantly points to the difficulty of defining or circumscribing the generic groups in the grand gradational series of modifications of the Proboscidian order, for the knowledge of which science is mainly indebted to Kaup, Clift, and Falconer.

STEGODON ORIENTALIS, Ow.

The molar of *Stegodon sinensis*, above described, alleged to be "from marly beds in the vicinity of Shanghai," showed by its colour and mineralized condition that it had been derived from some such, probably tertiary, deposit.

The portions of proboscidian molars which I have next to notice are in a less altered condition. The dentine retains its original white colour, and has only lost its soluble constituent, which causes it to adhere, like chalk, to the tongue; the enamel also has its recent pearly tint; a thick mass of cement appears to have been retained in the intervals of the coronal ridges.

One of these ridges, with the contiguous halves of two others, form a molar two inches nine lines in breadth (Pl. XXVIII. figs. 1 & 2); a portion of a posterior ridge with a low basal heel, from the same, or the same-sized tooth, and the last two ridges, with a terminal half ridge or talon, of a milk-molar, one inch and a half in breadth (ib. figs. 3 & 4), represent the present species.

These fragments form part of the series of teeth obtained by Mr. Swinhoe, and said to be "from a cave, near the city of Chung-king-foo, in the province of Sze-chuen." The condition of the fragments agrees with the statement, viz. that they were from a cavern.

In the largest fragment a longitudinal extent of grinding-surface of two inches includes the summits of three ridges. The basal breadth of the ridge (ib. fig. 2) *b b* is one inch; its height (unworn) is one inch four lines, measured along the sloping side. One slope, I think the anterior, is rather more inclined than the other. The ridge (ib. fig. 1) *a a* runs straight, or nearly so, across the tooth; the entire ridge is cleft at the summit into about a dozen mamillæ by as many vertical grooves; the dentine rises into the base of each mamilla. The enamel (*e*) averages two lines in thickness.

From the above-defined characters it is plain that we have here, also, parts of a "transitional Mastodon," in other words, a species of *Stegodon*, Fr. In the straight, or nearly straight, direction of the coronal ridges, and the absence of any trace of mid cleft, these molar fragments more resemble the teeth of *Stegodon Cliftii*, *St. insignis*, and *St. ganesa* of Falconer than does the *St. sinensis*; and

* 'Odontography,' *Proboscidia*, Section 228.

† "*Elephas* we divide into three sectional groups, viz. *Stegodon*, being the species which Owen calls *Transitional Mastodons*, the *M. elephantoides* of Clift, and of which there are three, and perhaps four, Indian fossil species."—*Palæontol. Memoirs*, vol. i. p. 20.

‡ Palæontological Memoirs, vol. ii. p. 9.

in the apparent quantity of coronal cement (ib. fig. 2 *c*) as well as in the evidence of a hinder talon (ib. fig. 3 *t*), they are more like *St. insignis* than *St. Cliftii*. Yet the two hinder ridges, with the terminal talon of the tooth (ib. figs. 3 & 4), which, in breadth, corresponds with the second upper deciduous molar of *St. insignis* and *St. sinensis*, clearly differ from both. The last two ridges run straighter across, are of the same extent, and are divided by more numerous vertical grooves into smaller and correspondingly numerous apical mamillæ. The second of these ridges is cleft in the middle.

From the alleged conditions of discovery, and the little-altered condition of the above-described portions of proboscidian molars, one would be led to deem them to be of as comparatively recent geological age as our ordinary British Cave-fossils. The section, however, of Proboscidia to which they indubitably belong has not hitherto been known to be represented by fossils of later age than of an upper miocene or older pliocene period.

I believe the ground to be good for indicating this second kind of Chinese proboscidian as *Stegodon orientalis*, Ow.

Hyæna sinensis, Ow.

The genus *Hyæna*, Storr, Cuv., is represented, in the present collection, by an upper premolar, *p* 3 (Pl. XXVIII. figs. 5 & 6), a lower premolar, *p* 3 (ib. fig. 7), and by a lower canine.

The upper premolar is from the right side of the jaw: it exceeds in antero-posterior diameter that tooth in *Hyæna crocuta*, is still larger than that of *Hyæna brunnea**, and is nearly double the size of that in the existing Asiatic species, *Hyæna striata* seu *vulgaris*. The main cone is relatively lower than that in *H. crocuta*; its outer vertical contour is more convex; and this comparison I have been careful to make with a specimen of the recent Cape species having *p* 3 worn in precisely the same degree as the Chinese tooth, viz. with the apex of the cone just abraded sufficiently to expose a speck of dentine. The hinder basal talon (fig. 5, *t*) is larger in *Hyæna sinensis*; and a tubercular production abuts upon the hind ridge of the main cone as in *Hyæna striata*. The antero-internal tubercle (fig. 6, *a*) is relatively less than in *Hyæna striata*: the ridge rising from it toward the tip of the main cone is as prominent as in *Hyæna crocuta*. As in that species, there is no trace of cingulum along the outer side of the base of the crown, which is so well marked in *Hyæna striata*. In the main, the generic character of this massive bone-cracker is closely held by the Chinese cave-tooth.

The third upper premolar of *Hyæna spelæa*, like the rest of the dentition, closely accords with that in *Hyæna crocuta*; consequently the distinctions above noted equally hold in differentiating the Chinese *p* 3 from that of the Hyæna from our own caverns.

I come next to the comparison with the fossil remains of *Hyæna* from the Siwalik tertiaries, *Hyæna sivalensis* of Baker and Durand†. The third upper premolar is smaller in the Siwalik Hyæna than in

* *Hyæna fusca*, Bl., Ostéographie (*Hyæna*), pl. iii.

† Journal of the Asiatic Society, October 1835, vol. iv. p. 569. See also Falconer, 'Palæontological Memoirs,' i. p. 548.

Hyæna crocuta, and consequently still smaller than in *Hyæna sinensis*. The difference of size, however, between *H. sivalensis* and *H. crocuta* is much less than that between *H. crocuta* and *H. striata*; consequently the Siwalik Hyæna was larger than that now existing in Hindostan, although less than that which once roamed in China. In the shape of the chief cone, however, of *p* 3, upper jaw, *H. sivalensis* more resembles *H. sinensis* than it does either of the above-named existing species of *Hyæna*. I refer to the character of greater vertical convexity of the outer side of the crown of the chief cone. In the posterior talon and the antinternal ridge of enamel of *p* 3, *H. sivalensis* more closely conforms with the *H. crocuta* than does *H. sinensis*, and departs from the *H. striata* in a minor development of both posterior and anterior basal tubercles. The external basal cingulum is also wanting in *H. sivalensis* as in *H. sinensis*. The degree in which the Chinese *Hyæna* surpassed in size that from the Red Crag of Suffolk will be appreciated by comparing fig. 5, Pl. XXVIII., with fig. 6 in pl. viii. of Ray Lankester's able memoir on *Hyæna antiqua*, in the 'Annals and Magazine of Natural History,' third series, vol. xiii.

Differences of like kind and value are shown by the second lower premolar (*p* 3 of the type series) of *Hyæna sinensis*, as compared with *H. crocuta*, *H. striata*, and *H. sivalensis*. The crown is broader both antero-posteriorly and transversely, but is lower vertically, than in *H. crocuta*; it is consequently a stronger cone: its qualities for cracking and crushing bone are intensified. The ridge continued upward from the anterior basal talon is stronger than in *H. crocuta*; it is more completely an upward production of the talon itself; and this is less defined as an anterior tubercle than in *H. striata*. The superior size of *H. sinensis* to *H. sivalensis* is more marked in the comparison of the lower premolar than in that of the upper one. Besides the superiority of size, the inner side of the chief cone is more convex vertically and transversely, more bulging, in the Chinese than in the Siwalik Hyæna; it more resembles, in this particular, the much smaller tooth of *Hyæna striata*.

The two fangs in both upper and lower premolars are deeply grooved along the surfaces turned towards each other; the hinder fang is entire in the specimen of the upper premolar from the cave near Chung-king-foo.

The canine has lost the apical half of its crown, but closely accords in form and in its transversely lineate back ridge with that of *Hyæna crocuta*; in size it conforms with the premolars above described.

	Upper *p* 3.			Lower *p* 3.		
	Hyæna sinensis.	*H. crocuta.*	*H. sivalensis.*	*H. sinensis.*	*H. crocuta.*	*H. sivalensis.*
	lines.	lines.	lines.	lines.	lines.	lines.
Antero-posterior diameter	12	11	$10\frac{1}{4}$	$11\frac{1}{2}$	10	$9\frac{1}{2}$
Vertical diameter	10	12	9	11	12	$9\frac{1}{2}$

On the foregoing grounds it may be inferred that the *Hyæna* which has left its remains in the Chinese cave was fully as powerful an animal as the *Hyæna spelæa* of Europe. It was of a distinct species, and, like the feebler one from the Red Crag, manifested, by the development of the tubercle from the hind part of the basal ridge of the third upper premolar, a tendency to a combination of the dental characters on which mainly modern taxonomists have rested in the generic distinction of the two best-marked forms of existing Hyæna (*Crocotta maculata*, Kaup, and *Hyæna striata*). Ray Lankester has well remarked on this instance of "divergence of types as we ascend the geological ladder," which his *H. antiqua* afforded. The only question is, whether *H. sinensis* may not have climbed to as high a rung, before it finally fell, as did the *H. spelæa*. The specimens above described have undergone less change from their recent state than have many of the teeth of *H. spelæa* from British caves.

The fossil specimens representing the *Hyæna sivalensis*, B. and D., and F. and C., are in the museum of the Asiatic Society of Bengal, in that of Dr. Jameson at Suharunpoor, and in the British Museum. Of the teeth of the lower jaw the notice is restricted to the fact of their "being larger than in the existing *Hyæna*"*; but whether the Indian or the S. African species, is not stated. From the above admeasurements, however, it is obvious that the existing species of India was meant, viz. the *Hyæna vulgaris* seu *striata*.

Rhinoceros sinensis, Ow.

The genus *Rhinoceros* is represented by portions of four upper molars, and of as many lower molars, in two of which the crown is nearly entire.

The most perfect of the upper molars is the last of the left side, *m* 3 (Pl. XXIX. figs. 1 & 2) including the elongated lobes *c*, *d*, continued inward from the outer tract of dentine (here broken away), together with the dividing valley, *e*. The fore and rear sides of the tooth converge outwardly, and the hinder lobe has no indent or valley penetrating it from that side; both which characters determine the place of the tooth in question. The postinternal lobe or ridge (*d*) sends a short broad simple promontory †, *p*, into the valley *e*. There is no tubercle or ridge at the entry to that valley, which runs sinuously outward and forward of nearly uniform depth to the end. The fore part of the cingulum (*r*) descends from the origin of the antinternal lobe (*c*) to the inner side of its base, where it subsides; the hind part of the cingulum is represented by a short thick lobular ridge (r^1) at the inner and back part of the postinternal lobe, *d*. The enamel, two millimetres in thickness at the fore part of the grinding-surface, thins off to less than half a millimetre over the promontory and end of the valley. In size the molar, as far as it is preserved, agrees with the corresponding tooth in *Rhinoceros sumatranus*; the fore-and-aft diameter of its inner side is one inch nine lines.

* Falconer, 'Palæontological Memoirs,' vol. i. p. 343.

† Hist. of Brit. Foss. Mamm. p. 374.

The second specimen consists of a smaller proportion of the inner part of a penultimate or antepenultimate molar, with evidence of the notch or valley penetrating from the hinder side of the crown. The promontory, running from the postinternal lobe into the valley entering from the inner side of the crown, resembles in simplicity of form that of the preceding tooth. The ridge at the back part of the base of the postinternal lobe is likewise very thick. A small mammilloid process projects near the entry to the valley *e*. The bases of the two inner fangs are preserved.

A first molar (*m* 1), abraded to the base of the crown, agrees in size and in so much of character as is preserved with the foregoing specimens; it exemplifies that of the valley *e*, inasmuch as, although the terminal bed is brought to the level of the grinding-surface, it is not insulated. The outer side of the tooth is broken away.

The outer enamel-wall (Pl. XXIX. fig. 3), with a small portion of adherent dentine, of a fourth upper molar, not forming part of any of the other three teeth, shows a strong vertical columnar bulge (*a*) terminating at the apex of the antexternal lobe, as in *Rhinoceros sumatranus*; but it also has a second, well defined, but less prominent, vertical ridge (*b*) rising to the apex of the postexternal lobe, the two ridges dividing the outer surface of the crown into three facets. In *Rhinoceros sumatranus* this character distinguishes the premolars from the true molars; but the second or hinder ridge of the outer enamel-wall is less defined in that species; and in the present tooth the middle facet is not uniformly concave from before backward, but undulates, through the projection, near the hinder boundary ridge, of a lower longitudinal rising of enamel. The apices of the two outer lobes (*a*, *b*) are more prominent than in *Rhinoceros sumatranus*; and the angular contour of that border of the tooth makes a closer resemblance than in Rhinoceroses generally to the outline of the same part in *Palæotherium*.

The fossil upper molars of the species of *Rhinoceros* from Ava, figured by Clift*, are much worn; but, as in the Chinese molar in the same condition, the closed and somewhat deeper end of the valley (*e*) is not insulated, as it is in all the Siwalik kinds at the same stage of attrition. The Avan teeth, however, indicate a larger animal than the Chinese species, and are more satisfactorily differentiated by the absence of the second longitudinal ridge (Pl. XXIX. fig. 3, *b*) on the outer wall of enamel.

From *Rhinoceros platyrhinus*, Fr.†, the Chinese species differs, both in the contour of the outer wall of the upper molar, and in the simplicity of the promontory. From *Rhinoceros sivalensis*, *Rh. sinensis* differs in the contour of the outer wall, in the thicker or broader promontory, and in the more uniform depth of the valley (*e*), whereby its termination is not insulated as in the specimen figured in pl. 75. fig. 5 of the 'Fauna Antiqua Sivalensis.' The same differences forbid a reference of the Chinese upper molars to *Rhinoceros palæindicus*; and both this and the *Rhinoceros sivalensis* were

* Trans. Geol. Soc. second series, vol. ii. pl. 40. fig. 1.

† Fauna Antiqua Sivalensis, pl. 72. fig. 6.

species of larger size. The Chinese Rhinoceros, in this respect, seems to have agreed with the two-horned kind of Sumatra, but to have had a different pattern of upper molar.

The lower molars from the cave of Chung-king-foo, of which there are parts of four, sufficiently exemplify the generic modification of *Rhinoceros*, but are too few and too much worn and mutilated for worthy evidence of specific distinction. I believe myself justified, from the characters of the upper molars, and the results of the comparisons above detailed, in indicating the Chinese Rhinoceros as *Rh. sinensis*, Ow. The enamel is, in most parts, smooth and not thick; it retains the natural colour; and the dentine, of chalky whiteness, is absorbent from loss of the soluble constituent, and not otherwise altered.

The main characteristics of the upper molars of this extinct species are evenness of depth of the main valley, its encroaching promontory thick and simple, unusually good indications on the outer enamel-wall of the two lobes (*a*, *b*) composing the thick continuous outer tract of dentine which is the characteristic of the present genus of Perissodactyle.

Considering remoteness of position, and the evidence pointing to still greater remoteness in geological time between the present and other known fossil Asiatic Rhinoceroses, I should have been more surprised to find identity of species, than to detect the indications of diversity which have above been noted.

Tapirus sinensis, Ow.

To the genus of Tapir are referable three molars of the upper, and four of the lower jaw. They resemble the other fossils from the Chinese cavern in colour and chemical composition; the dentine and portions of jawbone adherent to the fangs of the teeth are blanched and absorbent from loss of animal matter, but not mineralized.

Of the existing species of *Tapirus* these teeth most resemble those of the Sumatran kind (*T. malayanus*, Raffles, *T. indicus*, Cuv.). In the upper molar series there are modifications of grinding-surface which help to define the position in that series of such detached teeth.

The tooth, Pl. XXVIII. fig. 8, resembles the third or the fourth premolar in the degree of equality of the rear (*b*, *d*) with the front (*a*, *c*) half of the crown, and in the smaller proportion of the antexternal tubercle (*r*) of the cingulum; it more resembles the third premolar in the extension of the cingulum at the rear of the crown (*r*) to the inner end of the base of the postinternal lobe (*d*), such rear portion of the cingulum not being bent up to the apex of that ridge as in the last premolar and in the true molars of *Tapirus indicus*.

Compared with the tooth of the Sumatran species, with which it is homologous, this penultimate premolar of the Chinese Tapir is larger, and has a proportionally greater transverse diameter, or from without inwards; it is still larger than in the European fossil species.

Dimensions of p 3 in	*Tapirus priscus.*		*T. sinensis.*		*T. malayanus.*	
	in.	lines.	in.	lines.	in.	lines.
Greatest transverse diameter	0	$11\frac{1}{2}$	1	3	1	1
Antero-posterior diameter...	0	$10\frac{1}{2}$	1	0	0	11

Among minor differences may be noted a better development in the Chinese tooth of the inner extension of the hind part of the cingulum (r'), and a ridged production of opposite sides of the contiguous bases of the two elongate compressed conical lobes (c, d) at their inner ends, meeting, as it were, to close the inner entry to their dividing valley, e.

Compared with *Tapirus priscus*, from the Eppelsheim miocene, the Chinese tooth is still larger than it is in comparison with the Sumatran species, and its transverse extension of crown is greater; the degree is given in the above admeasurements*. The fangs are broken away from this premolar; and in the hollow of the post-external root were crystals, determined by my friend and colleague, Professor Maskelyne, to be calcite in complete scalenohedra, a form or condition of carbonate of lime commonly met with in limestone caves. This was satisfactory in the degree in which it was confirmatory of the statement that the fossils were from a cave.

The next molar, in the degree of transverse contraction of the hinder half of the crown, answers to the penultimate molar, m 2; it is from the left side; the pulp-cavity, exposed by the breaking away of the fang, is partially filled with a reddish earth.

Dimensions of m 2 in......	*Tapirus priscus.*		*T. sinensis.*		*T. malayanus.*	
	in.	lines.	in.	lines.	in.	lines.
Transverse diameter	1	0	1	3	1	2
Antero-posterior diameter...	0	10	1	2	1	0

The part of the cingulum continued inward from that which bends up the back part of the rear ridge is better developed in *Tapirus sinensis* than in *Tapirus malayanus*.

The third upper molar (Pl. XXVIII. fig. 9) is the last of the right side, and repeats the differential characters, as to size, of the two preceding molars, as compared with *Tapirus malayanus* and *T. priscus*. The antexternal root is preserved, part of the postexternal one, and the base of the confluent pair supporting the inner side of the crown (c, d); in the cavity of the fang, exposed by fracture, were also crystals of calcite. The divergence of the outer and inner fangs carries the transverse breadth of that part of the tooth much beyond the same diameter of the crown.

In the left lower penultimate premolar, p 3 (Pl. XXIX. fig. 6), besides a difference of size as compared with its homologue in *Tapirus malayanus*, there is a marked superiority of development of the ridge (t), continued from the outer angle of the anterior lobes (a) forward and inward, circumscribing a cavity in front of that lobe,—also in the height of the corresponding ridge from the outer angle of the

* It may also be estimated by comparing fig. 8, Pl. XXVIII. with fig. 9, p. 231, 'Quarterly Journal of the Geological Society,' vol. xii. 1856, "Upper molar of *Tapirus priscus*, from the Crag of Suffolk."

posterior lobe (*b*), which extends forward to abut upon the back part of the anterior lobe. These differences repeat characteristics seen in the anterior lower premolar, *p* 2, of *Tapirus malayanus*; but the transverse development of the anterior lobe in the present specimen shows it to be the succeeding premolar, *p* 3; and there is an abraded spot on the enamel of the fore part of the crown, proving it to have been preceded by another tooth, viz. that which answers to *p* 2 in the type series, but which is the foremost of the lower grinders in all Tapirs.

The first lower molar, *m* 1, right side, of *Tapirus sinensis* (Pl. XXIX. fig. 5) exceeds its homologue in *T. malayanus* by one line in both transverse and fore-and-aft diameters of the crown; the enamel is thicker, but the characters of the accessory ridges are less marked than in *p* 3. If the figure of the Chinese lower molar be compared with that of the lower molar of *Tapirus priscus* from the Red Crag of Sutton (Quarterly Journal of the Geol. Soc. vol. xiii. p. 233, figs. 8 *a*, 8 *b*), the difference of dimensions will be appreciated. The second lower molar, *m* 2, left side, repeats the differential characters of the foregoing as compared with its homologue in *Tapirus malayanus*. The posterior fang of this tooth is preserved to a length of one inch seven lines; its anterior surface shows the deep longitudinal, almost angular, channel which traverses that part, the hind surface of the fang being almost flat. There are fragments of another right lower molar of the same species of *Tapirus*, which, on the grounds above stated, I may be justified in defining as *Tapirus sinensis*. The differences observable in the molars of the American species of Tapir being greater and more numerous than those noticed in the Sumatran species as compared with the Chinese specimens, I have not spent time in their specification.

Remains of *Tapirus* appear not to have been met with in the Indian tertiaries. In Europe they have been found in the miocene of the Bourbonnais, and the pliocene of Auvergne, in the Eppelsheim miocene, and in the Red Crag at Woodbridge and Sutton. The Crag Tapir, like the Crag Hyæna, was much smaller than the Chinese species.

Mr. Swinhoe has been so good as to send me a copy of a figure of a quadruped called the "White-encircled Moh," from the old Chinese dictionary of Urh-ya, which dates from the commencement of the Christian era. This figure combines the head of an elephant, with its large pendent ears and long proboscis, with the trunk of a Tapir, the mane and bushy tail of a horse, and pentadactyle hind feet. It is worthy of a passing notice, however, because the trunk shows the diversity and arrangement of contrasted colours which are peculiar to the Malayan and Sumatran Tapirs. It may also be remarked that the Tapir has a mid tract of erect stiff hairs along the upper surface of the neck, exemplifying a certain correspondence with the one-hoofed perissodactyles, and it has a rudimental proboscis. Opinions, of course, will vary as to the source of the figure of the "white-encircled" proboscidian and maned quadruped in the old Chinese

work, viz. whether from a Tapir which continued to exist in China to within the historic period, or from figures and descriptions, brought home by some Chinese voyager, of the species now existing in the Malaccan promontory and in Sumatra.

Mr. Swinhoe writes to me that the Tapir "has long since ceased to be an animal known to the Chinese, and has given rise to many fables, which are repeated in Chinese dictionaries, and in the great Chinese Herbal, 'Pun-tsao-Kang.'"

It is satisfactory, therefore, to have acquired indisputable evidence that a Tapir, nearly allied to, but larger than the Sumatran kind, has existed in China, and has left its remains in conditions of preservation and entombment corresponding with those of large spelæan mammals, some of which were the latest to die out, and others still exist, in Europe.

It also adds to the illustration afforded by the existing Malaccan Tapirs of the original tract of dry land from which the Malaccan peninsula is nearly, and Sumatra quite insulated.

Chalicotherium sinense, Ow.

The last specimen from Mr. Swinhoe's Chinese spelæan teeth, that will be noticed in the present paper, is an upper molar of the right side, the last of the series, *m* 3 (Pl. XXIX. figs. 7, 8, 9 & 10), with the pattern of grinding-surface of that genus of Anoplotherioid from the Eppelsheim miocene which Kaup distinguished and named *Chalicotherium**.

In the upper true molars of this genus the crown has an outer and an inner division; the outer one presents an anterior (*a*) and a posterior (*b*) lobe, the former the larger; both are hollowed externally (*f*, *f'*), with a thick convex dividing bulge (*n*), the indent (*f*) being bounded by a similar convexity (*o*) anteriorly.

The coronal projection of each lobe is angular (fig. 7, *a b*), and inclines to the apex inwardly, as in *Anoplotherium*, fig. 11. The outer surface of the hind lobe (*f'*) looks obliquely backward and outward, and is turned most backward in the last molar (as in fig. 7), and to a greater degree than in *Anoplotherium*. The inner division of the crown consists of the postinternal lobe (*d*) and the mammilloid cone (*m*)—an antinternal lobe not being marked off, as in *Paloplotherium* and *Anoplotherium* (fig. 11, *c*), by the extension of the fissure (*l*) from the fossa (*h*). The valley *e* (Pl. XXIX. fig. 7) is wide and deep, and is joined at the fossa (*h*) by the valley *k*, which is of similar size; the entry to each valley is partially bounded by a development (*r*, *r*) of the cingulum, or basal ridge. The postinternal lobe (*d*) is marked off, as usual, by an indent or valley from *b*.

The cingulum may be traced from the low ridge along the fore side of the base of *a* to its thicker portion (*r*) at the entry of the valley, *k*, whence it is continued more feebly along the inner side of the base of *m* to join the ridge at the entry of the valley *e*: it thence extends just recognizably along the inner side of *d*, where it subsides.

The cingulum reappears along the rear of the base of the lobe *b*,

* Ossemens fossiles de Darmstadt: obl. fol. 1833.

and less conspicuously along the outside of the base of the lobe *a*. The middle of the outer concavity of this lobe shows a narrow vertical ridge of the enamel, ending a little behind the apex of the lobe.

In the anterior view of the crown (fig. 9) the convexity of the prominence (*o*) in the vertical direction is shown, and the degree of inflection of the outer surface inward to form the apex (*a'*) of the V-shaped summit of the antexternal lobe; the cone (*m*) simulates in this view an antinternal lobe. The absence of this lobe is characteristic of *Chalicotherium*; I do not regard the part of the cingulum (*r*) as its rudiment, because it is present in the premolars as well as in the molars, and it coexists with the true representative of the antinternal lobe (*c*) in both *Paloplotherium* and *Anoplotherium* (fig. 11, *r*).

The posterior view of the crown (Pl. XXIX. fig. 8.),in like manner, gives the vertical curve of the dividing bulge, and shows the proximity to the inner side of the tooth of the apex of the lobe *b*; the second or postinternal lobe forms the cone *d*. The inner side of the tooth (*ib.* fig. 10), formed by the cone *m*, and the postinternal lobe (*d*), with the uniting cingulum (*r*), is much narrower than the outer side; and the inner division shows consequently a confluence of its roots (*t*). This molar was implanted by two thick and strong outer roots, and by one larger inner root, composed, as indicated by the inner and outer longitudinal impressions, of two confluent fangs.

With the aid of the pocket-lens the fine transverse striæ of the enamel appear, and best beyond the cingulum. The radical cement is rough and thick. The dentine is blanched, not petrified, but has lost gelatine, and sticks like chalk to the tongue, as in the other cave-fossils.

The reader comparing fig. 7, Pl. XXIX., with *m* 3, fig. 36, pl. 80, of the 'Fauna Antiqua Sivalensis,' fol., or with figs. 5 and 6, *a*, pl. 7, of Kaup's 'Ossemens Fossiles de Darmstadt,' oblong fol., and with the excellent figure of the upper molar, apparently *m* 3 of *Chalicotherium Goldfussi*, in Bronn's 'Lethæa Geognostica,' atlas, fol. taf. xlvi. fig 2, *a*, may appreciate the grounds for indicating the Chinese Anoplotherioid as *Chalicotherium sinense*.

The last molar of *Chalicotherium sinense* is less than that of *Ch. Goldfussi*, Kp., and two lines larger in all the dimensions given at p. 431, than is that tooth in *Ch. sivalense*, Fr. Compared with this, the outer bulge (*o*) of the antexternal lobe is thicker, more convex vertically, and more produced outwardly. The outer concavity of the postexternal lobe (*f'*), which in *m* 3 becomes almost backward in aspect, is less deep in *Ch. sinense*; it is angularly indented in *Ch. sivalense*. The basal ridge (*r*) between the two inner lobes and that anterior to the base of the mammilloid lobe (*m*), are relatively less developed in *Ch. sinense*. The Anoplotherioid character of this lobe, as a large, rather low cone, is well marked. Its summit and the angular margin of the antexternal lobe are worn to the dentine, the exposed tract in the latter being from one to two lines in breadth. The enamel of the anterior part of the ridge of the postexternal and postinternal lobes is abraded, and the dentine beneath, at the fore part of these lobes, is partially exposed. The anterior part of the

interval between the postexternal (*b*) and the postinternal (*d*) lobes is not closed by a ridge descending from the summit of the post-external lobe as in *Chalicotherium sivalense* *: nor does the inner side of the antexternal lobe terminate in so ridge-like a way as in *Ch. sivalense*; it is more rounded. The inner side of the postinternal lobe (*d*) is rounded in *Ch. sinense*, not angular as in *Ch. sivalense* †. The following are admeasurements of the last molar (*m* 3′) of the two species of *Chalicotherium*.

Admeasurements of the last Upper Molar.

	C. sinense.		*C. sivalense.*	
	in.	lines.	in.	lines.
Fore-and-aft diameter of outer side	1	7½	1	4
,, ,, inner side	1	2½	1	0½
Transverse diameter of fore side	1	8	1	6
,, ,, near side	1	6½	1	3½

Falconer observes of the molars of *Chalicotherum sivalense*, "their width is greater than their length" (*tom. cit.* p. 192); but the direction of these dimensions is not defined. In *Chalicotherium sinense*, as in *Ch. sivalense*, the diameter from without inwards equals that from before backwards. In speaking of the length of a tooth, one ordinarily means the extent to which the crown projects from the socket; and this is commonly the "vertical diameter" of the crown. In this sense the length of the molars of *Chalicotherium* is much less than their breadth, whether transverse or antero-posterior. But, then, this inferiority of length does not differentiate the molars of *Chalicotherium* from those of *Anoplotherium*. The length of the entire tooth in both genera, which includes the implanted part, is greater than any other diameter or dimension. The difference in the mineral condition of this Chinese cave-tooth and the fossil teeth of the same genus from the upper Miocene of France, Germany, and India is very striking and suggestive.

The older Chalicotherian molars, recognized by Kaup and Lartet, are truly petrified fossils. Those also from the Siwalik sands are in this state; but Falconer remarks that, when clay is the matrix, the bones, and, we may presume, the dentine of the teeth, remain white, and, except in being deprived more or less completely of their animal matter, they have undergone little alteration (*tom. cit.*

* This structure is noticed by the careful and minute observer Falconer, as follows:—"The apex of the posterior reentering angle gives off a like transverse ridge, which sweeps round into the posterior side." (Palæontological Memoirs, 8vo, vol. i. p. 192).

† The differential structure in *Chalicotherium sivalense* is noticed as follows, in the same useful and instructive summary of his scientific thoughts and works:—"This is the 'transverse ridge,' which is much inclined downwards and joins on with the isolated conical cusp (a, a', a'') in the anterior and inner corner of the tooth, a cusp characteristic of *Anoplotherium*." (Falconer, Palæontological Memoirs, vol. i. p. 192.) I may, however, remark that the conical cusp is equally characteristic of *Paloplotherium*, and, though of smaller size, of *Hipparion*.

p. 190). The Chalicotherian fossils are said to be in this latter state; but both bone and dentine of the original specimens in the British Museum are more mineralized and discoloured by the matrix than is the tooth from China here described.

The correspondence, in colour, chemical condition, matrix, and cavernous locality, of the tooth of *Chalicotherium sinense* with those of Bovine and other Ruminants, of Hyæna, Rhinoceros, and Tapir, which are alleged, and with every appearance of truth, to be from the same cave, supports the inference of a correspondence of geological age in regard to the introduction therein of the individuals of those genera and families which have yielded the remains now described. If the Anoplotherioid molar had not been in the series, such series would have been referred, without hesitation, to a geological period not older than Upper Pliocene, and with a possibility of Postpliocene age.

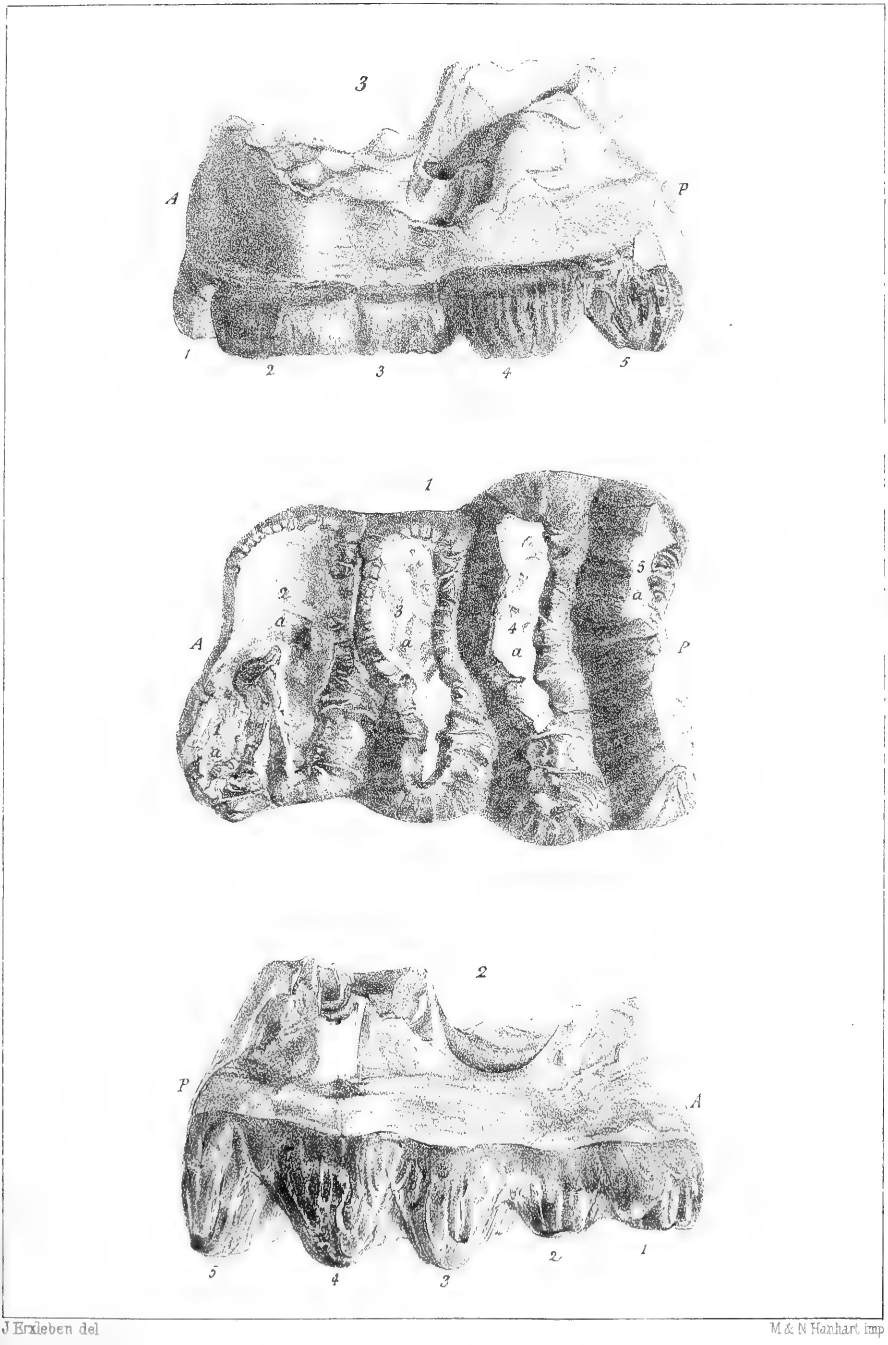
I accept the evidence of the majority of the fossils, with the older alternative, and conclude that this particular anoplotherioid Artiodactyle which has departed from the generalized character of the type-genus by the suppression of a premolar on each side of both jaws, and the commencement of a diastema or break in the dental series, continued to exist in China until the pliocene division of tertiary time, perhaps to a late period of that division.

I may remark that the Chalicotherian modification has not hitherto been found in older tertiary deposits than miocene. It indicates the course or characters of derivative change in the Artiodactyle series, in a manner interestingly analogous to that shown by *Anchitherium* and *Acerotherium* in the Perissodactyle series.

In both great primary groups of hoofed Mammals this change is manifested, in the dental system, by arrest of development at the fore part of the series, especially in the upper jaw. When no teeth there arrive at full growth, the offensive and defensive weapons called horns usually make their appearance; median and odd in the Perissodactyle Rhinoceros, in a pair or pairs in the Artiodactyle ruminants, with well-known exceptions, not, however, affecting a statement of general tendency. *Chalicotherium*, in the diminished size of the premolars, in the transverse disposition of the incisive alveoli of the mandible (traces of which are visible in the original of the figure 1, pl. 80, of the 'Fauna Antiqua Sivalensis'*), and in the contiguous small canines, makes a close step to the Ruminant dentition, as it does also in the molar formula, $p\,\frac{3-3}{3-3}$, $m\,\frac{3-3}{3-3}$, and in the diastema between these and the fore teeth. Upper canines as well as incisors failed, as in most Ruminants, to attain development. This view of Chalicotherian modifications in the Artiodactyle series may not meet with general acceptance; but I think it is preferable to the notion of *Chalicotherium* having been a kind of cross between *Anoplotherium* and *Rhinoceros*.†

* Originally in the Dadoopoor Collection of Messrs. Baker and Durand, and now in the Museum of the Marischal College, Aberdeen.

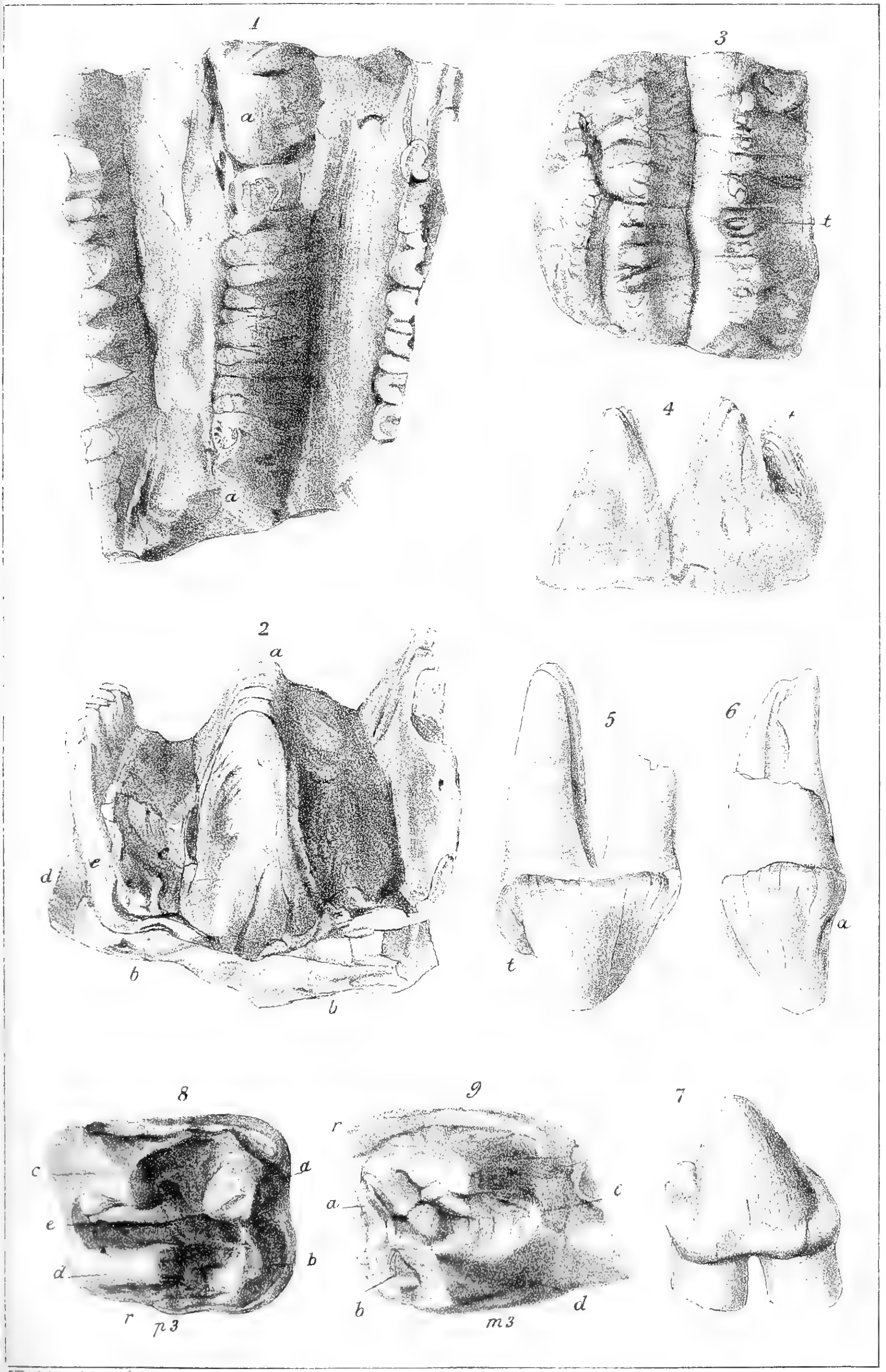
† Falconer characterizes the *Chalicotherium sivalense* as "one of the most



J. Erxleben del.

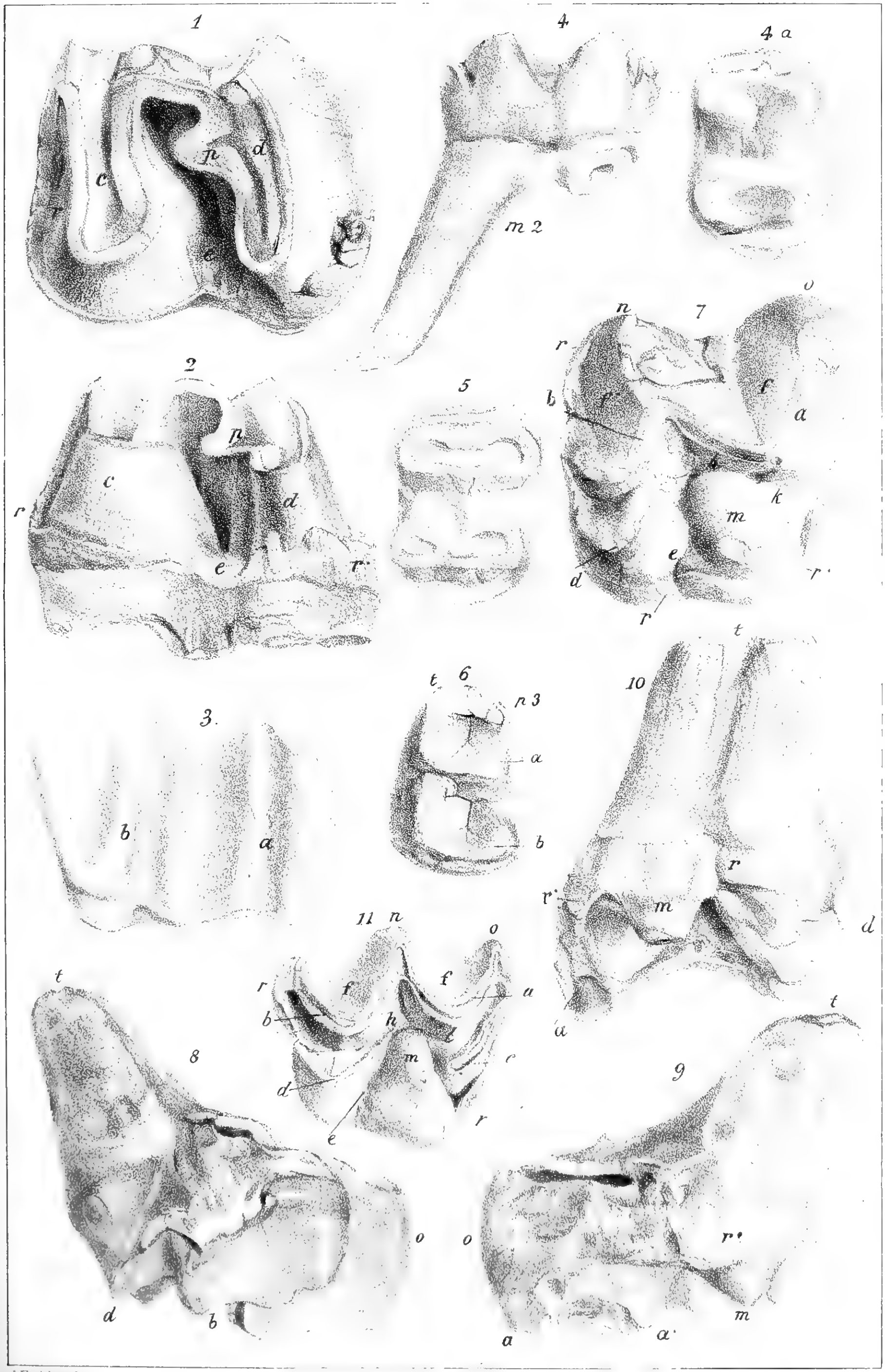
M & N Hanhart imp.

CHINESE FOSSIL MAMMALS



J. Erxleben del. M. & N. Hanhart imp.

CHINESE FOSSIL MAMMALS



J. Erxleben del.

M & N Hanhart imp.

CHINESE FOSSIL MAMMALS.

The extent of the range of the species of *Chalicotherium* over the great division of dry land to which that form seems to have been restricted, was considerable, viz. from France to China. In tracing it in this direction, the species appear to have lived on nearer to the present period as they were located eastward.

At Sansan, as at Eppelsheim, the remains of *Chalicotherium* have become petrified in beds of miocene age, now covered by later tertiaries. In the caverns of Greece (Pikermi &c.) they are associated with Upper Miocene and Old Pliocene forms. In the teeth from the Siwalik deposits, although the Chalicotherian dentine, in some degree, and as contrasted with that of the sandstone fossils of the same locality, may come into the category of the "soft fossils," yet they are far from presenting the appearance and evidence of comparatively recent unchangedness which characterizes the dentine of the teeth from the Sy-chuen cave.

Land at the eastern limits of the great Europæo-Asiatic tract, and now forming China, may have been exempt, or much longer exempt (since it became fit to be trod by tapirs and anoplotherioids) from those alternate elevations and depressions which have destroyed, have modified, or have covered with deposits of Pliocene and Post-pliocene age the western Miocene land*.

DESCRIPTION OF THE PLATES.

Plate XXVII.

Stegodon sinensis.

Fig. 1. Second upper molar, *d* 3, grinding-surface,
2. " " outer side view.
3. " " inner side view.

Plate XXVIII.

Stegodon orientalis.

Fig. 1. Portion of true molar, grinding-surface.
2. " " side view.
3. Hind end of milk-molar, *d* 3, grinding-surface.
4. " " side view.

Hyæna sinensis.

Fig. 5. Third upper premolar, right, *p* 3, front view.
6. " " " outer side view.
7. Second lower premolar, *p* 3, outer side view.

Tapirus sinensis.

Fig. 8. Third upper premolar, *p* 3, grinding-surface.
9. Last upper molar, *m* 3, " "

---

remarkable aberrant Pachyderms that have yet been met with, closely allied to *Anoplotherium*, but showing a return from the ruminant tendencies of the Cuvierian species back to a more pachydermatous type, and a closer affinity with Rhinoceros, between which and *A. commune* it may ultimately prove to be an intermediate form."—*Palæontological Memoirs*, vol. i. p. 22, and p. 195.

* Other fossils were obtained by Mr. Swinhoe from a vendor of drugs at Shanghai, such fossils being collected and sold as articles of the Chinese Materia Medica. An esteemed medical friend has referred me to an old work showing that fossils were collected in Europe for the same purpose in the middle ages.

PLATE XXIX.

Rhinoceros sinensis.

1. Last upper molar, *m* 3, grinding-surface.
2. " " inner side view.
3. Upper molar, outer enamel-wall.

Tapirus sinensis.

4. Second lower molar, *m* 2, outer side view.
4*a*. " " grinding-surface.
5. First lower molar, *m* 1, grinding-surface.
6. Second lower premolar, *p* 3, grinding-surface.

Chalicotherium sinense.

7. Last upper molar, *m* 3, grinding-surface.
8. " " rear view.
9. " " front view.
10. " " inner side view.

Anoplotherium commune, Cuv.

11. Upper true molar, from a Montmartre specimen in the British Museum.

DISCUSSION.

The CHAIRMAN called attention to the remarkable association of forms among the fossils described by Prof. Owen.

Prof. BUSK remarked that the materials at command seemed to him insufficient for the establishment of new species. He observed that the distinctive characters of *Stegodon sinensis* appeared to be very slight, and that the *Hyæna* might just as probably be *H. spelæa*. The tooth of *Rhinoceros* might be a milk-molar of *R. sumatranus* or *R. sondaicus*.

Mr. BOYD DAWKINS suggested that, as the specimens were obtained from apothecaries, there was no evidence of the contemporaneity of the fossils.

Mr. H. WOODWARD stated that Mr. Swinhoe had himself obtained a series of these fossils from a cave many miles inland—he believed, on the course of the Yang-tse-kiang. Mr. Woodward also called attention to Mr. Hanbury's paper on Chinese Materia Medica, in which many fossil teeth of mammalia are noticed.

Prof. OWEN, in reply, stated that great quantities of the fossils had passed through his hands, and that he had selected for description those which, from their minute agreement in chemical and other characters, might justly be inferred to be of the same age, and to be derived from the cave mentioned by Mr. Swinhoe.

---

3. *Further discovery of the* FOSSIL ELEPHANTS *of* MALTA. By Dr. A. A. CARUANA.

[Communicated by Dr. A. Leith Adams, F.G.S.]

(Abstract.)

THE author described the discovery of some fossil bones in a fissure at Is-Shantiin, at the entrance of the quarry of Micabibba, on the 24th of January of the present year.

The fissure in which the bones were found was an expansion of a

narrow vertical rent, varying in width from 3 to 5 inches, and filled, as usual, with red earth and fragments of stone, which may be traced from the surface of the rock, traverses the sandstone quarry for a distance of 60 feet, and runs on, constantly increasing in depth, towards the south-south-west, in the direction of the Gandia fissure, with which it probably unites at a distance of less than a quarter of a mile. The expanded portion of the fissure in which the bones were found was in the shape of half a barrel cut through the flat ends; and it measured from 2 to 3 feet in width, 10 feet in length, and a little more than 6 feet in depth. It was covered by a large block of sandstone. The sides of the fissure were, as usual, perfectly smooth. It had no stalagmitic floor.

The fissure was filled with a compact deposit of red earth, with fragments of limestone, containing throughout teeth and fragments of bones of fossil elephants, associated with bones of large birds, as in the Gandia fissure; but no shells were observed. A tooth, which the author supposed to be that of a *Hippopotamus*, was also obtained*. The author also met with three small fish-teeth.

The remains of Elephants obtained from this fissure consist chiefly of fragments of the long bones. Several of the Elephants' teeth were entire, and they were generally rather better preserved than those discovered in the Gandia fissure. A fragment of a tusk, 21 inches in length, was obtained; the greatest circumference of this was 17 inches, or 2 inches more than the specimen found by Dr. A. Leith Adams at Tal-Maghlak.

This fissure at Is-Shantiin is said by the author to raise the number of localities in Malta in which Elephant-remains have been found in abundance to five, namely:—the cave at Casal Zebbug, discovered in 1859 by Capt. Spratt; two caves at Tal-Maghlak, in Casal Krendi, discovered by Dr. A. Leith Adams in 1861; the Gandia fissure, within the limits of Casal Micabibba and Casal Siggeni, excavated in 1865 by Dr. Adams and the author; and the Is-Shantiin fissure at the entrance to Casal Micabibba. These localities are all in the denuded district of the eastern half of the island; and in this direction there is abundant evidence of the existence of many similar ossiferous fissures. From the mode of occurrence of these bones the author infers that, at the time of their deposition where we now find them, that part of the island was exposed to the impetuous wash of continuous and rapid currents of fresh water. The remains already found indicate the existence of three species of Elephants, two or more species of *Hippopotamus*, one species of gigantic Dormouse and other large extinct animals, which must have wandered over the island in large numbers, probably associated with Carnivora, of which, however, no remains have been discovered in Malta, although the author has found a portion of the lower jaw of *Hyæna* in the island of Gozo. He considered that the area of the island was wholly inadequate for the shelter and support of so many large mammals, and, considering their affinity to African species, and certain hydrographical conditions noticed by Capt. Spratt, he inferred that, at the

* See Dr. Adams's note at the end of this paper.

period when these mammals were living, Malta must have been united to the African continent.

Note by Dr. A. Leith Adams, F.G.S.

I have received from Dr. Caruana the tooth he supposes may belong to an Hippopotamus, and find it is a fragment of a germ true molar of one or other of the pigmy Elephants. The fish-teeth are also in my possession, and referable to Sharks of the genus *Lamna* or *Oxyrhina*, and are very probably Miocene, and derived from the rocks in which the Shantiin fissure exists, having been washed into it along with the soil and other organic remains. Similar teeth were found in Zebbug Cave by Captain Spratt, F.G.S.; and I discovered allied Sharks' teeth in another ossiferous cavern in the island.

DISCUSSION.

Prof. BUSK remarked that there was no doubt that three species of elephants had lived and bred in Malta.

Capt. SPRATT said that, it appeared to him, the chief interest of the communication lay in the greater comparative abundance of the larger species of elephant in the new locality.

DONATIONS

TO THE

LIBRARY OF THE GEOLOGICAL SOCIETY.

From January 1st to March 31st, 1870.

I. TRANSACTIONS AND JOURNALS.

Presented by the respective Societies and Editors.

Academy (Journal). Nos. 4–6. January to March 1870.

American Journal of Science and Arts. Second Series. Vol. xlviii. No. 144. November 1869.

J. D. Dana and G. J. Brush.—On the Magnetite in Mica of Pennsbury, Pa., in reply to Prof. G. Rose, 360.
S. F. Peckham.—On the probable origin of Albertite and allied minerals, 362.
J. P. Kimball.—Notes on the Geology of Western Texas and of Chihuahua, Mexico, 378.
O. C. Marsh.—Notes on some new Mosasauroid Reptiles from the Greensand of New Jersey, 392.
——. Description of a new and gigantic fossil Serpent (*Dinophis grandis*) from the Tertiary of New Jersey, 397.

——. ——. Vol. xlix. No. 145. January 1870.

W. D. Alexander.—On the Crater of Haleakala, Island of Maui, Hawaiian group, 43.
F. W. Clarke.—On a new method of separating Tin from Arsenic, Antimony and Molybdenum, 48.
E. Billings.—Notes on the structure of the Crinoidea, Cystidea and Blastoidea, 51.
T. S. Hunt.—On Laurentian Rocks in Eastern Massachusetts, 75.
J. L. Smith.—Account of a fall of meteoric stones near Danville, Ala., with an analysis of the same, 90.

American Naturalist. Vol. iii. Nos. 10–12. December 1869 to February 1870.

Archives Néerlandaises des Sciences Exactes et Naturelles. Vol. iv. 1869.

Athenæum (Journal). Nos. 2200–2212. January to March 1870.

J. J. Lake.—Geology of Cork Harbour, 27.
W. H. Baily.—Geology of Cork Harbour, 97.
Surveys and Explorations in India, 295.
G. H. Kinahan.—The Rocks of the South-west of Ireland, 391.

Berlin. Monatsbericht der königl.-preussischen Akademie der Wissenschaften zu Berlin. November and December 1869.

Ehrenberg.—Mittheilung aus einem Schreiben des Hrn. Dr. Haast, 752.

——. Sitzungsberichte der Gesellschaft naturforschender Freunde zu Berlin im Jahre 1869.

Kunth.—Ueber die Entwickelung der *Zoantharia rugosa*, 8.
Virchow.—Knochen und Geweihstücken von vaterländischen Thieren der Vorzeit, 30.

——. Zeitschrift der deutschen geologischen Gesellschaft. Band xxi. Heft 4. August to October 1869.

E. Becker.—Ueber fisch- und pflanzenführende Mergelschiefer des Rothliegenden in der Umgegend von Schönau in Niederschlesien, 715.
F. Richthofen.—Ueber das Alter der goldführenden Gänge und der von ihnen durchsetzten Gesteine, 723.
J. D. Whitney.—Ueber die in Californien und an der Westküste Amerikas überhaupt vorkommenden Mineralien u. Grundstoffe, 741.
Websky.—Ueber Epiboulangerit, ein neues Erz, 747.
——. Ueber wasserhellen Granat von Jordansmühl in Schlesien, 753.
Richter.—Devonische Entomostraceen in Thüringen, 757 (2 plates).
Zeuschner.—Die Gruppen und Abtheilungen des polnischen Juras, nach neueren Beobachtungen zusammengestellt, 777.
Kosmann.—Der Apatit von Offheim und der Kalkwavellit von Dehrn und Ahlbach, 795.
C. Rammelsberg.—Ueber die Isomorphie von Gadolinit, Datolith und Euklas, 807.

Bordeaux. Mémoires de la Société des Sciences Physiques et Naturelles de Bordeaux. Tome v. 1867.

——. Extrait des Procès-verbaux des Séances de la Société des Sciences Physiques et Naturelles de Bordeaux. 1867.

Caen. Bulletin de la Société Linnéenne de Normandie. 2e Série. 1er volume. Année 1865–66.

L. de La Sicotière.—Sur des empreintes nombreuses visibles à la surface d'un rocher de grès de Bagnoles (Orne), 83.
J. A. Eudes-Deslongchamps.—Réponse à cette lettre, 89.
Schlumberger.—Communication sur le crétacé de l'Algérie, 91.
E. Eudes-Deslongchamps.—Observations à ce sujet, 91.

Caen. Bulletin de la Société Linnéenne de Normandie. 2e Série. 1er volume (*continued*).

Schlumberger.—Notes paléontologiques, 92.
E. Eudes-Deslongchamps.—Observations sur les *Aptychus* et les *Anaptychus*, considérés comme pièces intégrantes de l'animal des Ammonites, 104.
J. A. Eudes-Deslongchamps.—Remarques sur l'os de la mâchoire inférieure des Téléosauriens, désigné sous le nom de complémentaire, 112.
E. Eudes-Deslongchamps.—Sur les fossiles du système oolithique inférieur du royaume de Hanovre, 118.
J. A. Eudes-Deslongchamps.—Note sur un tronçon de mâchoire supérieure d'une espèce nouvelle de téléosaure, 121.
Marc.—Note sur trois molaires d'*Elephas primigenius* et leur gisement, 129.
J. A. Eudes-Deslongchamps.—Remarques sur la communication de M. l'abbé Marc, 134.
——. Note sur un groupe de vertèbres et d'écailles rapportées au *Teleosaurus hastifer* et provenant des argiles kimméridgiennes du cap la Hève, 146.
E. Eudes-Deslongchamps.—Note sur des céphalopodes et des crustacés renfermés dans la cavité abdominale de poissons et de reptiles des argiles infraoolithiques, 156.
Morière.—Une vertèbre de saurien fossile, 171.
J. A. Eudes-Deslongchamps.—Observation au sujet de cette communication, 172.
E. Eudes-Deslongchamps.—Note sur les genres *Trochotoma* et *Ditremaria*, 215.
——. Note sur les *Leptomaria* et *Cryptœnia* démembrés du genre *Pleurotomaria* et sur quelques espèces nouvelles appartenant à ces trois genres, 221.
——. Note sur plusieurs espèces nouvelles de gastéropodes provenant de la couche à *Ammonites Sauzei*, 247.
J. A. Eudes-Deslongchamps.—Note sur trois espèces de Téléosauriens du calcaire de Caen se rapprochant du premier type crée par Geoffroy-Saint-Hilaire sous le nom de *Teleosaurus cadomensis*, 326.
E. Eudes-Deslongchamps.—Observations zoologiques et géologiques sur la côte de Port-en-Bessin, 352.

——. ——. 2e volume. Année 1867.

E. Jardin.—Mémoire sur le Surtabrandur d'Islande, sur les anciennes forêts et sur le reboisement de cette île, 8.
E. Eudes-Deslongchamps.—Note sur le squelette et la restauration du *Teleosaurus cadomensis* (and several other Steneosaurian Reptiles), 381.

Calcutta. Asiatic Society of Bengal. Proceedings. No. 10. October 1869.

——. Journal of the Asiatic Society of Bengal. New Series. Part 1. No. 3, and Part 2. No. 4. 1869.

Cambridge (Mass.). Bulletin of the Museum of Comparative Zoology at Harvard College. Nos. 8–13.

Canadian Journal of Science, Literature, and History. New Series. Vol. xii. No. 4. November 1869.

E. J. Chapman.—Analyses of some Canadian Minerals, 265.

Canadian Naturalist and Geologist. Vol. iv. No. 3.

E. Billings.—Notes on the structure of the Crinoidea, Cystidea, and Blastoidea, 277.
T. R. Jones.—'Fossil Bivalved Entomostraca,' noticed, 336.
— Crosskey.—Boulder Clay, 349.

Chemical News. Vol. xxi. Nos. 526–538.

Chemical Society. Journal. Second Series. Vol. viii. January to March 1870.

Christiania. Det Kongelige Norske Frederiks-Universitetets Aarsberetning for Aaret 1868, med Bilage. 1869. (2 copies.) *From the Royal Norwegian University in Christiania.*

——. Forhandlinger i Videnskabs-Selskabet i Christiania. Aar 1868. Christiania, 1869.

K. Pettersen.—Profil gjennem Reisenelvens Dalföre udover Ulö og Kaagen til Lyngenfjord, 316.

——. Index Scholarum in Universitate Regia Fredericiana Centesimo duodecimo eius Semestri. Anno 1869. XVII. Kalendas Februarias habendarum. (2 copies.) *From the Royal Norwegian University in Christiania.*

Colliery Guardian. Vol. xviii. Nos. 469 & 470.

——. Vol. xix. Nos. 471–481.

Cornwall. Laws and Rules of the Royal Geological Society of Cornwall.

Dresden. Sitzungs-Berichte der naturwissenschaftlichen Gesellschaft Isis in Dresden. Jahrg. 1869. Nos. 7–9. July to September.

Dr. Günther.—Ueber ausgestorbene Thierarten, 118, 135.
J. G. Bornemann.—Zur Kritik der mikroskopischen Entdeckungen des Herrn Bergrath Dr. Jenzsch, 141.
C. R. Schumann.—Ueber Torfmoore, 160.
E. Zschau.—Eine Pseudomorphose vom Grube Churprinz bei Freiberg, 166.
——. Avanturinfeldspath, von den Norwegern Sonnenstein genannt, 167.
——. Ueber die Orthoklasfeldspathe Norwegens, 167.

Edinburgh. Geological Society. Transactions. Vol. i. Part 3. 1870.

J. Haswell.—On Columnar Structure developed in Mica Schist from a Vitrified Fort in the Kyles of Bute, 229.
A. Somervail.—On the Depth of the Seas in which the Carboniferous Limestone was formed, 249.
D. W. Roberts.—Notice of certain Concretions found in the Upper Silurian Rocks of Denbighshire, North Wales, 253.

Edinburgh. Geological Society. Transactions. Vol. i. Part 3 (*continued*).

J. Henderson.—Notice of recent Fossiliferous Sandstone and Clay at Granton, 255.
J. Haswell.—Notice of Sandstone now in the course of formation at Elie, Fifeshire, 259.
E. Hull.—On the Extension of the Coal-fields of England under the more recent Permian and Triassic Formations, 261.
J. Henderson and D. J. Brown.—On the Silurian Rocks of the Pentland Hills, 266 (1 plate).
W. L. Lindsay.—Preliminary Report on the Sutherlandshire Goldfield, 273.
H. A. Nicholson.—Notes on the Geology of Derwentwater, in Cumberland, 274 (1 plate).
W. Jolly.—Notes on the Geology of Southerness, Kircudbrightshire, 278.
J. Powrie.—On the earliest known vestiges of Vertebrate Life; being a Description of the Fish Remains of the Old Red Sandstone Rocks of Forfarshire, 284 (5 plates).
G. Anderson.—On Vitrified Forts, with Description of Craig Phadrich, near Inverness, 302.
R. Brown.—On the Geographical Distribution and Physical Characteristic of the Coal-fields of the North Pacific Coast, 305.
G. Lyon.—Notes on the Trap-dykes of Edinburgh and neighbourhood, 325.
D. W. Roberts.—Notice of the occurrence of "*Actinocrinus pulcher*" (Salt. MSS.), in the Upper Silurian Flags of Denbighshire, North Wales, being a new locality for this Encrinite, 329 (1 plate).
J. Croll.—On two River Channels buried under Drift, belonging to a period when the land stood several hundred feet higher than at present, 330 (1 plate).
R. Dick.—On the Discovery of a "Sand-dyke," or old river channel running north to south, from near Kirk of Shotts to Wishaw, Lanarkshire, 345 (1 plate).
A. Taylor.—Notes on Chemical Geology, 352.
Field-day at Campsie; being Notes on the Joint Excursion of the Edinburgh and Glasgow Geological Societies to Campsie Glen, Dunglass Castle, and the Spout of Ballygan, June 1869, 355.

——. Proceedings of the Royal Society of Edinburgh. Session 1868–69.

T. C. Archer.—Note on an undescribed variety of Flexible Sandstone, 485.
D. Milne-Home.—On the Boulder-clay of Europe, 529.
——. On the Basin of the Firth of Forth, and some of its Geological Phenomena, 550.
J. J. Murphy.—On the Causes of Volcanic Action, 583.

Einsiedeln. Protokoll der geologisch-mineralogischen Sektion an der Versammlung der Schweizerischen Naturforschenden Gesellschaft in Einsiedeln. August 1868. (2 copies.)

Electric Telegraph and Railway Review. Vol. i. Nos. 8–10.

Floral World and Garden Guide. New Series. No. 12. 1869.

Florence. Bollettino del Reale Comitato Geologico d'Italia. No. 1. January 1870.

Frankfort-on-the-Main. Abhandlungen herausgegeben von der Senckenbergischen naturforschenden Gesellschaft. Band VII. Hefte 1 & 2.

F. Hessenberg.—Mineralogische Notizen, No. 8, 1–46 (4 plates).
F. Scharff.—Ueber die Bauweise des Feldspaths. II. Der schiefspaltende Feldspath, Albit und Periclin, 47–48 (2 plates).

——. Bericht über die Senckenbergische naturforschende Gesellschaft in Frankfurt am Main. Von Juni 1868 bis Juni 1869.

Geological Magazine. Vol. vii. Nos. 1–3. January to March 1870.

D. Forbes.—On the Contraction of Igneous Rocks in Cooling, 1.
J. Rofe.—On some supposed Lithodomous perforations in Limestone Rocks, 4 (plate 1).
J. Ruskin.—Banded and Brecciated Concretions, 10 (plate 2).
J. C. Ward.—On the Denudation of the Lake District, 14.
S. V. Wood, jun.—Observations on the Sequence of the Glacial Beds, 17, 61.
T. Codrington.—Some Remarks on the Formation of the Chesil Bank, 23.
D. Mackintosh.—Terraces on Inland Slopes: reply to G. Poulett Scrope, 25.
Prof. Owen.—On some New Zealand *Plesiosauri*, 49 (plate 3).
J. Geikie.—On the age of the Croft-head Deposits near Glasgow, 53.
O. Fisher.—Contraction of Rocks in Cooling, 58.
T. S. Hunt.—The Liquefaction of Rocks, 60.
D. C. Davies.—The Millstone Grit of the North Wales Border, 68, 122.
T. R. Jones.—Notes on Cretaceous Entomostraca, 74.
J. Hopkinson.—On a new Silurian Annelide, 77.
H. Woodward.—British Fossils—the Lias Pterodactyle, 97 (plate 4).
P. Scrope.—The Character of Lavas, 100.
Miss C. Eyton.—On the Pleistocene Beds of N. Shropshire, 106.
Miss E. Hodgson.—On the Situation of the Iron-ore Fossils in Water-Blain Mines, 113.
T. Blanford.—On Faults in Strata, 115.
G. H. Kinahan.—On Faults in Strata, 118.
J. E. Taylor.—The Sand-pipes in the Chalk, Norwich, 119.
H. Abich.—'On some Remarkable Forms of Hailstones observed in Georgia,' noticed, 26.
Prof. Kner.—'Description of *Conchopoma* and restored figure of *Acanthodes*. Abstracted by Dr. C. Lütken,' noticed, 29.
C. Lütken.—'On the Fossil Ophiuridæ,' noticed, 79.
'The Great Boulder-Drift of N. America,' noticed, 127.
R. Owen.—'On a new Fossil Bird,' noticed, 129.
Desor and Loriol's 'Echinologie Helvétique,' reviewed, 30.
Pattison's 'Slate and Slate-quarries Geologically and Commercially considered,' reviewed, 32.
Seeley's 'Index to the Fossil Birds and Reptiles in the Woodwardian Museum,' reviewed, 34.
Capt. Oliver's 'Geology of St. Helena,' reviewed, 82.

Geological Magazine. Vol. vii. Nos. 1–3 (*continued*).

Proceedings of Societies, 36, 85, 129.
Correspondence, 46, 92, 140.
Miscellaneous, 143.
Obituary, 96.

Halifax (N. S.). Proceedings and Transactions of the Nova-Scotian Institute of Natural Sciences. Vol. ii. Part 3. 1868–69.

J. Rutherford.—On a Peculiarity in the Blockhouse Seam, Cow Bay, Cape Breton, 18.
H. Poole.—On the Meteorology of the Glacé Bay Coal-district, 100.
H. Y. Hind.—Notes on the Structure of the Nova Scotia Gold-districts, 102.
— How.—Notes on the Economic Mineralogy of Nova Scotia, 128.
R. G. Haliburton.—Explorations in the Pictou Coal-field in 1867 and 1868, 155.
J. W. Dawson.—Notes on New Points and Corrections in Acadian Geology, 166.
R. C. Harris.—On an Important Reclamation of Land near Sackville, 170.

Iron and Coal Trades Review. No. 97. January 5, 1870.

Linnean Society of London. Journal. Vol. x. Zoology, No. 47, 1870; and Vol. xi. Botany, No. 52, 1869.

——. Proceedings. 1869–70.

Liverpool. Abstract of the Proceedings of the Liverpool Geological Society. Session 1868–69.

G. H. Morton.—Notes on the Geology of the Breidden Hills, 33.
C. Ricketts.—The Geology of the Neighbourhood of Ingleborough, 34.
C. Potter.—Observations on the Cheshire Coast, 37.
R. Bostock.—The New Red Sandstone as a Source of Water-supply, 58.
H. Hicks.—Notes on the Arenig Rocks in the neighbourhood of St. David's, 72.
G. H. Morton.—Palæontological Observations on the Carboniferous Limestone in Flintshire, 75.
N. Tate.—On the Chemistry of the Primæval Earth, 77.
J. Roberts.—On the Wells and Water of Liverpool, 84.
G. H. Morton.—The Geology of the Country around Shelve, Shropshire, with a Notice of the Breidden Hills (41 pages and 4 plates).

London, Edinburgh, and Dublin Philosophical Magazine. Fourth Series. Vol. xxxix. Nos. 258–260. January to March, 1870. *From Dr. W. Francis, F.G.S. &c.*

J. A. Phillips.—Note on certain Slates (Felsites and Elvanites) occurring near Knockmahon, in the County of Waterford, 12.
Geological Survey of Scotland, 81.

Longman's Notes on Books. No. 60. February 1870.

Medical Press and Circular. New Series. Vol. viii. Nos. 24–26.

Medical Press and Circular. New Series. Vol. ix. No. 1.

Milan. Atti della Società Italiana di Scienze Naturali. Vol. xii. Fasc. 2. October, 1869.

Monthly Microscopical Journal. Nos. 13–15. January to March, 1870.

W. Carruthers.—On the structure of the stems of the arborescent Lycopodiaceæ of the Coal-measures, 144.

Moscow. Bulletin de la Société Impériale des Naturalistes de Moscou. 1868. No. 4.

E. v. Eichwald.—Die *Lethæa rossica* und ihre Gegner. Zweiter Nachtrag, 311.
H. Trautschold.—Kimmeridge und Néocomien, 460.
R. Hermann.—Untersuchungen verschiedener Mineralien, 491.

Munich. Sitzungsberichte der königl.-bayer. Akademie der Wissenschaften zu München. 1869. Band i. Heft 4, and Band ii. Hefte 1 & 2.

F. Pfaff.—Ueber das Eindringen des athmosphärischen Wassers in den Boden, 125.

Nature (Journal). Vol. i. Nos. 8–20.

A. Geikie.—The Gold-fields of Victoria, 210, 233.
J. Prestwich.—The Thames Subway, 280.
A. R. Wallace.—The Measurement of Geological Time, 399, 452.
T. H. Huxley.—On the Progress of Palæontology, 437.
A. Geikie.—Geology of the Holy Land, 509.

Newcastle-upon-Tyne. Transactions of the Iron and Steel Institute. Vol. i. No. 4. 1869.

News List and Index of Daily and Periodical Publications and Magazines. No. 1. January 1870.

Palæontographical Society. Vol. xxiii. Issued for 1869. 1870. (2 copies.)

P. M. Duncan.—Supplement to the Fossil Corals. Part II. No. 2. (Cretaceous), 6 plates.
T. Wright.—The Cretaceous Echinodermata. Vol. I. Part 3 (10 plates).
J. Phillips.—The Belemnitidæ. Part V. (Oxford Clay &c. Belemnites), 9 plates.
J. Powrie and E. Ray Lankester.—The Fishes of the Old Red Sandstone. Part I. (concluded), 9 plates.
R. Owen.—The Reptilia of the Liassic Formation. Part II. (4 plates).
——. The Crag Cetacea. No. 1 (*Ziphius*), 5 plates.

Palermo. Giornale di Scienze Naturali ed Economiche del Istituto Tecnico di Palermo. Vol. v. Fasc. 3 & 4. 1869.

G. G. Gemmellaro.—Studii Paleontologici sulla Fauna del calcario a *Terebratula janitor* del nord di Sicilia, 257.

Paris. Bulletin de la Société Géologique de France. Deuxième Série. Tome xxvi. No. 4.

Ebray.—Recherches sur l'inclinaison des couches jurassiques à l'ouest des Alpes dauphinoises, 393.
Dieulafait.—Zone à *Avicula contorta* et Infra-lias dans le midi de la France (Ardèche, Lozère, Aveyron, Hérault), 398 (plate 4).
Hébert.—Observations sur les couches inférieures de l'Infra-lias du midi de la France, 447.
Dieulafait.—Réplique aux observations ci-dessus, 452.
D'Archiac.—Note sur le genre *Fabularia*, Defrance, 454.
Garrigou et Duportal.—Ages de l'Ours, du Renne, de la pierre polie et des dolmens dans le département du Lot, 461.
Meugy.—Sur le Lias, 484.
Jacquoit.—Observations sur la note ci-dessus, 513.
Meugy.—Réplique, 515.
Peron.—Sur les terrains jurassiques supérieurs en Algérie, 517.
Cotteau.—Sur les Echinides du terrain jurassique supérieur d'Algérie, 529.
——. Sur les Echinides fossiles receuillis en Syrie par M. Louis Lartet, 533.
Tombeck.—Sur quelques fossiles coralliens trouvés à Saint-Claude près Chambéry, 540.
Coquand.—La Craie, sa composition géologique et son origine, 541.

——. Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences. Deuxième Semestre 1869. Tome lxix. Nos. 19–22.

G. Planté.—Mémoire sur les lignites inférieurs de l'argile plastique du bassin parisien, 1012.
— Guignet.—Composition chimique et formation des couches de la grande oolithe et du forest-marble dans la Haute-Marne, 1028.
— Jackson.—Sur les mines de cuivre du lac Supérieur et sur un nouveau gisement d'étain dans l'État du Maine, 1082.
Hamy et Lenormant.—Découverte de restes de l'âge de pierre en Égypte, 1090.

——. Tables des Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences. Tome lxviii.

Photographic Society. Journal. Nos. 213–215. January to March 1870.

Quarterly Journal of Science. No. 25. January 1870.

R. Tate.—The Fuller's-earth in the south-west of England, 68.
Chronicles of Geology and Mineralogy, 114, 124.

Quekett Microscopical Club. Journal. No. 9. January 1870.

Report of the Proceedings of the Geological and Polytechnic Society of the West Riding of Yorkshire. 1869.

J. S. Tute.—On certain natural pits in the neighbourhood of Ripon, 2.
E. Tindall.—Remarks on the extinct Fauna of the East Riding of Yorkshire, 7.
L. C. Miall.—On a New Carboniferous Labyrinthodont from the neighbourhood of Bradford, 15.
H. Denny.—On the occurrence of Flint Implements at Adel, near Leeds, with suggestions as to the probable Period of their Deposit, 24.

Report of the Proceedings of the Geological and Polytechnic Society of the West Riding of Yorkshire. 1869 (*continued*).

T. W. Tew.—On the Rocks of the Neighbourhood of Pontefract; with some Observations on the Discovery of some bones of the *Bos primigenius*, 39.

J. Ffooks.—On the Bridlington Flint Implements, 99.

Revue des Cours Scientifiques de la France et de l'Étranger. Septième Année. Nos. 1–16.

M. A. Cazin.—Le percement du Mont-Cenis, 25.

A. Gaudry.—La théorie de l'évolution et la détermination des terrains. Les migrations animals aux époques géologiques, 44.

Congrès International d'Anthropologie et d'Archéologie Préhistoriques, 162, 200.

W. Carruthers.—Les Forêts Cryptogamiques de la Période Houillère, 194.

J. Delbos.—L'Alsace pendant la période tertiaire, 215.

— Hamy.—L'Homme Tertiaire en Amérique et la Théorie des centres multiples de création, 248.

T. H. Huxley.—L'Histoire de la création, 253.

Royal Agricultural Society. Journal. Second Series. Vol. vi. Part 1. 1870.

Royal Asiatic Society of Great Britain and Ireland. Journal. New Series. Vol. iv. Part 2. 1870.

Royal Geographical Society. Proceedings. Vol. xiv. No. 1. 1870.

Royal Society. Philosophical Transactions. Vol. clix. Part 1. 1869.

A. Newton.—On the Osteology of the Solitaire, or Didine Bird of the Island of Rodriguez, *Pezophaps solitaria* (Gmel), 327.

——. Proceedings. Vol. xviii. Nos. 115 & 116.

Royal Society of Edinburgh. Transactions. Vol. xxv. Part 2. 1868–69.

D. M. Home.—On the Boulder-clay of Europe, 655 (1 plate).

St. Petersburg. Bulletin de l'Académie Impériale des Sciences de St. Pétersbourg. Tome xiv. Nos. 1–3.

J. F. Brandt.—Sur le genre *Dinotherium*, réuni à la famille des Eléphants, et sur la craniologie comparée des genres de cette famille (extrait), 25–27.

G. v. Helmersen.—La houille de Malewka, 47–52.

——. Mémoires de l'Académie Impériale des Sciences de St. Pétersbourg. 7me Série. Tome xiii. No. 8.

——. ——. ——. Tome xiv. Nos. 1–7.

J. F. Brandt.—De Dinotheriorum Genere Elephantidarum Familiæ adjungendo nec non de Elephantidarum Generum Craniologia Comparata, No. 1.

——. Untersuchungen über die Gattung der Klippschliefer (*Hyrax*, Herm.), No. 2.

G. v. Helmersen.—Studien über die Wanderblöcke und die Diluvialgebilde Russlands, No. 7.

Scientific Opinion. Vol. ii. Nos. 58–61. December 1869.

H. A. Nicholson.—On the Occurrence of Plants in the Skiddaw Slates, 615.
C. F. Lütken.—A Remarkable Echinoderm, 635.
— Grant.—A Monster Canadian Bone-cave, 636.

——. Vol. iii. Nos. 62–72. January to March 1870.

T. H. Huxley.—On a Lump of Coal, 4.
W. R. M'Nab.—On the Structure of a Lignite from the Old Red Sandstone, 9.
S. Hunt.—Volcanoes and Earthquakes, 36, 63.
J. Morris.—The Miocene Flora, 65.

Scientific Summary. Vol. i. No. 1. January 1870.

Society of Arts. Journal. 116th Session. Nos. 892–904.

Diamonds in New South Wales, 135.

South Midland Institute of Mining, Civil, and Mechanical Engineers. Transactions. Vol. i. December 1869.

J. Randall.—Evidences of Denudation in and around the Shropshire Coal-field, 52, 85.
H. E. Colton.—The Preservation of Iron, 162.
Kjerulf.—The Terraces of Norway, 188, 215, 241.
C. U. Shepard.—Ambrosine, a new Organic Mineral Substance, 244.

Student and Intellectual Observer. Vol. iv. No. 24.

P. M. Duncan.—Corals and their Polypes, 445 (1 plate).

——. New Series. No. 1.

Oswald Heer.—The Miocene Flora of Spitzbergen, 84.
G. A. Lebour.—Geological Colours, 94.

Turin. Atti della Reale Accademia delle Scienze di Torino. Vol. iv. Disp. 1–7. November 1868 to June 1869.

Strüver.—Sulla Sellaite, nuovo minerale di fluorio, 35.
——. Su una nuova legge di geminazione dell' Anortite, 38.
Lanini.—Comunicazione di una Nota intorno alla costituzione dei terreni adiacenti alla via ferrata da Foggia a Napoli, 43.
Cossa.—Ricerche di chimica mineralogica, 187.
Sella.—Relazione sulla Memoria del Dott. Strüver intitolata: Studii sulla mineralogica italiana, Pirite del Piemonte e dell' Elba, 285.
Giordano.—Sulla orografia e sulla geologica costituzione del Gran Cervino, 304,
A. Sismonda.—Osservazione sulla Memoria precedente, 321.
Sobrero.—Di un nuovo combustibile fossile italiano analizzato dal Prof. Valerico Cauda, 638.
Gastaldi.—Sunto di una Memoria intitolata: Iconografia di alcuni oggetti di remota antichità rinvenuti in Italia, 755.
Sella.—Relazione sui lavori presentati all' Accademia sui terreni solforiferi della Sicilia, 756.

Turin. Atti della Reale Accademia delle Scienze di Torino. Vol. iv. Disp. 1–7 (*continued*).

Sobrero.—Analisi di minerali italiani eseguite dal Prof. Valerico Cauda, 757.
Cossa.—Sulla determinazione delle formole mineralogiche di alcuni carbonati romboedrici misti, 768.

——. Bollettino Meteorologico ed Astronomico del Regio Osservatorio dell' Università di Torino. 1868.

Vienna. Anzeiger der k.-k. Akademie der Wissenschaften. 1869. Nos. 27 & 28, and Title and Index.

——. Sitzungsberichte der k.-k. Akademie der Wissenschaften. Band lviii. Erste Abth. Hefte 1–5. 1868.

H. Wankel.—Schreiben an Herrn Prof. Hyrtl (Description of the cave of By'či skála), 7 (1 plate).
G. Tschermak.—Ueber Damourit als Umwandlungsprodukt, 16.
F. Karrer.—Die miocäne Foraminiferenfauna von Kostej im Banat, 121 (5 plates).
T. Fuchs.—Beitrag zur Kenntniss der Conchylienfauna des vicentinischen Tertiärgebirges. I. Abtheilung, 227.
E. Suess.—Ueber die Gliederung des vicentinischen Tertiärgebirges, 265.
A. E. Reuss.—Paläontologische Studien über die älteren Tertiärschichten der Alpen. Abth. II., 288.
E. Suess.—Bemerkungen über die Lagerung des Salzgebirges bei Wieliczka, 541 (map).

——. ——. Band lviii. Zweite Abtheilung. Hefte 2–5. 1868.

——. ——. Band lix. Erste Abtheilung. Hefte 1 & 2. 1869.

G. C. Laube.—Ueber *Ammonites Aon*, Münster, und dessen Verwandte, 7.
A. Manzoni.—Bryozoi Pliocenici Italiani, 17 (2 plates).
A. Boué.—Etwas über Vulkanismus und Plutonismus in Verbindung mit Erdmagnetismus, sowie ein Aufzählungsversuch der submarinischen brennenden Vulkane, 65.
E. Suess.—Ueber das Rothliegende im Val Trompia, 107 (2 plates).
G. C. Laube.—Ueber einige fossile Echiniden von den Murray Cliffs in Süd-Australien, 183 (1 plate).
T. Fuchs.—Eocän-Conchylien aus dem Gouvernement Kherson im südlichen Russland, 199.

——. ——. Band lix. Zweite Abtheilung. Hefte 1–3. 1869.

——. Verhandlungen der k.-k. geologischen Reichsanstalt. 1869. No. 16.

A. R. Rössler.—Ueber die Geologie der Gegenden jenseits des Mississippi-Flusses, 362.
J. Krejčí.—Offene Erklärung über Herrn Barrande's Colonien im Silurbecken von Böhmen, 363.

Vienna. Verhandlungen der k.-k. geologischen Reichsanstalt. 1869. No. 16 (*continued*).

J. Barrande.—Antwort auf Herrn Prof. J. Krejčí's obige Erklärung, 363.
W. von Haidinger.—Mittheilung Sr. kais. Hoheit des Herrn Erzherzog Josef über neue Brunnenbohrungen bei Alcsuth in Ungarn, 364.
A. Kornhuber.—Knochenreste aus den Wocheiner Bohnerz-Gruben, 364.
——. Knochenreste aus der Fuschlerhöhle an der Drachenwand im Salzburgischen, 365.
J. F. J. Schmidt.—(1.) Ueber die vulcanischen Erscheinungen zu Santorin, 366. (2.) Die Topographie der Mondoberfläche, 367.
C. von Beust.—Bemerkungen über das Erzvorkommen von Rodna in Siebenbürgen, 367.
A. Březina.—Krystallisirter Sandstein von Sievring nächst Wien, 370.
A. Holler.—Geologisch-paläontologische Skizze der Tertiärbildungen in der Umgebung von Laa an der Thaya, 372.
F. Foetterle.—Fossilien aus der Gegend zwischen Plewna und Jablanitza am nördlichen Gehänge des Balkan in Bulgarien, 373.
E. v. Mojsisovics.—Ueber cephalopoden-führenden Muschelkalk im Gosauthale, 374.

——. ——. 1870. Nos. 1–4.

M. v. Lipold.—Zu Herrn Krejčí's Erklärung über die Colonien im Silur-Becken von Böhmen, 1.
J. Barrande.—Antwort auf Herrn Lipold's obige Erklärung über die Colonien, 2.
J. Rumpf.—(1.) Ueber den Magnetkies von Loben bei St. Leonhard in Kärnten. (2.) Ueber Magnesit-Krystalle von Maria-Zell in Steiermark, 2.
C. von Ettingshausen.—Ueber die fossile Flora von Sagor in Krain, 3.
E. Suess.—Ueber das Vorkommen von Fusulinen in den Alpen, 4.
K. von Hauer.—Das Schwefelvorkommen bei Szwoszowice in Galizien, 5.
K. M. Paul.—Vorlage der geologischen Karte des nördlichsten Zempliner und Ungh'er Comitates, 8.
J. Nuchten.—Erdbeben in Grünbach, 17.
J. Krejčí.—Diamanten in Böhmen, 17.
A. Boué.—Alter der Granite. Fossile Algen, 18.
F. Pošepný.—Die Natur der Erzlagerstätte von Rodna in Siebenbürgen, 19.
——. Einige Beziehungen zwischen Erzlagerstätten und Dislocationen, 20.
V. von Zepharovich.—Nachträge zu F. v. Vivenot's "Beiträge zur mineralogischen Topographie von Oesterreich-Ungarn," 23.
E. Suess.—Neue Säugethierreste aus Oesterreich, 28.
J. Woldrich.—Ueber Gosaugebilde bei Salzburg, 30.
F. Karrer.—Ein neues Vorkommen von oberer Kreideformation in Leitersdorf bei Stockerau und dessen Foraminiferen-Fauna, 31.
H. Wolf.—Die geologischen Verhältnisse von Oedenburg, 33.
M. Neumayer.—Neue Cephalopoden-Arten aus den *Macrocephalus*-Schichten des Brielthales, 33.
D. Stur.—Zwei neue Farrnkräuter aus den Sotzka-Schichten von Möttnig in Krain, 33.

Vienna. Verhandlungen der k.-k. geologischen Reichsanstalt. 1870. Nos. 1–4 (*continued*).

Schrauf.—Meerschaluminit, ein neues Mineral von Simla in Indien, 43.
F. Karrer.—Ueber die Foraminiferenfauna der sarmatischen Stufe in den durch die neueren Brunnenbohrungen in Döbling, Grinzing, Brunn am Walde &c. erschlossenen Tegel-Schichten, 44.
W. Zsigmondy.—Ueber eine neuere Brunnenbohrung bei Lippik nächst Pakrac in Slavonien, 45.
Constantin v. Ettingshausen.—Ueber die fossile Flora von Leoben in Steiermark, 45.
M. von Mantken.—Geologische Untersuchungen im Bakonyer Wald, 58.
C. von Beust.—Ueber die Vercokungsfähigkeit verschiedener, bis jetzt nicht zur Cokesfabrication verwendeter Kohlensorten in Oesterreich, 59.
P. G. Hauenschild.—Ueber einige Reste der Glacialperiode im Alm- und Steyerlingthal, 61.
C. von Ettingshausen.—Ueber die fossile Flora des Tertiärbeckens von Bilin, 63.
G. Stache.—Vorlage der geologischen Karte der Umgebungen von Unghvär und Mandock im nordöstlichen Ungarn, 64.
K. M. Paul.—Die Gliederung des Kalkgebirges von Homonna im Zempliner Comitate, 64.

II. PERIODICALS PURCHASED FOR THE LIBRARY.

Annales des Sciences Géologiques. Tome i. No. 1. 1870.

L. Lartet.—Essai sur la Géologie de la Palestine et des contrées avoisinantes, 5.
E. Hébert.—Recherches sur l'âge des grès à combustibles d'Helsingborg et d'Höganäs, 117.

Annales des Sciences Naturelles. Zoologie et Paléontologie. 5e Série. Tome xii. Nos. 5 & 6. 1869.

Annals and Magazine of Natural History. Fourth Series. Vol. v. Nos. 25–27. January to March 1870.

J. Lycett.—On a Byssiferous Fossil *Trigonia*, 17.
A. Hancock and R. Howse.—On *Janassa bituminosa*, Schlotheim, from the Marl-slate of Midderidge, Durham, 47 (2 plates).
G. Cotteau.—On the Genus *Asterostoma*, belonging to the family *Echinocorydeæ*, 230.

Journal de Conchyliologie. Vol. x. No. 1. 1870.

L'Institut. 1re Section. 37e Année. Nos. 1874–1878.

Palæontographica: herausgegeben von Dr. W. Dunker und Dr. K. A. Zittel. Vol. xvii. Lief. 4. November 1869.

R. Ludwig.—Nachtrag zu der Abhandlung über fossile Pflanzen aus den paläolithischen Formationen in der Umgegend von Dillenburg, Biedenkopf und Friedberg und aus dem Saalfeldischen, 137.
W. Koeppen.—Ueber das Kieferfragment einer fossilen Katze aus Eppelsheim, als Beitrag zur Kenntniss des felinen Gebisses, 141.
E. Ehlers.—Ueber fossile Würmer aus dem lithographischen Schiefer in Bayern, 145 (7 plates).

——: ——. Vol. xix. Lief. 2. January 1870.

O. Böttger.—Neue Conchylien des Mainzer Tertiär-Beckens, 35 (2 plates).
O. Speyer.—Die Conchylien der Casseler Tertiärbildungen, 101 (6 plates).

III. GEOLOGICAL AND MISCELLANEOUS BOOKS.

Names of Donors in Italics.

Abich, H. Hailstones in Russian Georgia. 8vo. 1869. *From Prof. T. R. Jones, F.G.S.*

——. On Fulgurites in the Andesite of the Lesser Ararat, and on the Influence of Local Agents on the Production of Thunderstorms. 8vo. 1869. *From Prof. T. R. Jones, F.G.S.*

Agassiz, L. Address delivered on the Centennial Anniversary of the birth of Alexander von Humboldt. 8vo. Boston, 1869.

Annual Report of the Secretary of the Interior, showing the Operations of the Department for the year 1869. 8vo. Washington, 1869. *From the United States Government.*

Anonymous (*Tom Cringle*). About Coal-formations. 8vo. 1869.

——. Capital without Coin. 8vo. 1869.

——. Earthquake Waves: are they possible? 8vo. 1869.

Bauerman, H. A Treatise on the Metallurgy of Iron. 8vo. 1868.

Bianconi, G. G. Osservazioni sul Femore e sulla Tibia dell' *Æpyornis maximus.* 8vo. 1870.

Bonney, T. G. The Lofoten Islands.

Bristow, H. W., and W. Whitaker. On the Formation of the Chesil Bank, Dorset. 8vo. 1869.

Brown, R. On the Geographical Distribution of the Coniferæ and Gnetaceæ. 8vo. Edinburgh, 1869.

Brown, R. E. The Book of the Landed Estate, containing directions for the Management and Development of the resources of Landed Property. 8vo. 1869.

Carpenter, W. B. On the Temperature and Animal Life of the Deep Sea. 8vo. 1870.

Cotteau, M. G. Rapport sur les Progrès de la Géologie et de la Paléontologie en France pendant l'année 1868. 8vo. Le Puy, 1869.

Cowell, S. H. A Brief Description of the Art of Anastatic Printing. 8vo. 1869.

Croll, J. On the Influence of the Gulf-stream. 8vo. 1869.

——. On the Opinion that the Southern Hemisphere loses by Radiation more Heat than the Northern, and the supposed Influence that this has on Climate. 8vo. 1869.

——. On the Physical Cause of the Motion of Glaciers. 8vo. 1869.

——. On two River-channels buried under Drift, belonging to a period when the land stood several hundred feet higher than at present. 8vo.

Eichwald, E. von. Die 'Lethæa Rossica' und ihre Gegner. Zweiter Nachtrag. 8vo. Moscow, 1869.

Enniskillen, Earl of. Alphabetical Catalogue of the Type Specimens of Fossil Fishes in the Collection of the Earl of Enniskillen at Florence Court. 8vo. 1869.

Favre, A. De l'Existence de l'Homme à l'Époque Tertiaire. 8vo. 1870.

——. H.-B. de Saussure et les Alpes. 8vo. Lausanne, 1870.

Gæa Norvegica. Lieferungen 1–3. Fol. Christiania, 1838–50. *From the Royal Norwegian University in Christiania.*

Gorresio, G. Sunti dei Lavori Scientifici letti e discussi nella Classe di Scienze Morali, Storiche e Filologiche della Reale Accademia delle Scienze di Torino dal 1859 al 1865. 8vo. Torino, 1868.

Griesbach, C. L. Die Erdbeben in den Jahren 1867 und 1868. 8vo. Wien, 1869.

Hayden, F. V. Geological Report of the Exploration of the Yellowstone and Missouri Rivers. 8vo. Washington, 1869.

Hayden, F. V. Preliminary Field Report of the United States Geological Survey of Colorado and New Mexico. 8vo. Washington, 1869.

Hiortdahl, T. Om Underberget ved Kongsberg, og om Guldets Forekomst sammesteds. 8vo. Christiania, 1868. (2 copies.) *From the Royal Norwegian University in Christiania.*

Hochstetter, F. von, and A. Petermann. The Geology of New Zealand. 8vo. With Geological and Topographical Atlas. 4to. Auckland, 1864. *From Dr. C. F. Fischer.*

Hopkinson, J. On *Dexolites gracilis,* a new Silurian Annelide. 8vo. 1870.

Jervis, W. Guida alle Acque Minerali d'Italia. 8vo. Torino, 1868.

Jones, T. R. Notes on the Cretaceous Entomostraca. 8vo. 1870.

Jones, T. R., W. K. Parker, and J. W. Kirkby. On the Nomenclature of the Foraminifera. 8vo. 1869.

Kawall, J. H. Enneas Ichneumonidarum Curoniæ quas descripsit novas. 8vo. Moscow, 1869.

Kayser, E. Ueber die Contact-Metamorphose der körnigen Diabase im Harze. 8vo. Berlin, 1870.

Kenngott, Prof. Microscopical Investigation of thin Polished Laminæ of the Knyahynia Meteorite. 8vo. 1869. *From Prof. T. R. Jones, F.G.S.*

Kergomard, J. Essai Biographique sur Marie Rouault. 8vo. 1861. *From J. Prestwich, Esq., F.R.S.*

Lartet, E., and H. Christy. Reliquiæ Aquitanicæ; being contributions to the Archæology and Palæontology of Périgord and the adjoining provinces of Southern France. Part X. February 1870. *From the Executors of the late H. Christy, Esq., F.G.S.*

Lartet, L. Essai sur la Géologie de la Palestine et des Contrées avoisinantes telles que l'Égypte et l'Arabie. Première Partie. 4to. Paris, 1869.

Laube, G. C. Die Fauna der Schichten von St. Cassian. Abtheilungen 4 and 5. 4to. Wien, 1869.

Lea, I. Notes on Microscopic Crystals included in some Minerals. 8vo. 1869.

Leymerie, A. Catalogue des Travaux Géologiques et Minéralogiques publiés jusqu'en 1870. 8vo. 1869.

Lowe, E. J. Natural Phenomena and Chronology of the Seasons. 8vo. 1870.

Mallet, F. R. On the Vindhyan Series, as exhibited in the North-western and Central provinces of India.

Maps of the Geological Survey of Queensland. Cape-River Gold-fields, and Canal-Creek Diggings. *From the Geological Survey of Queensland.*

Marie Rouault, Directeur Conservateur du Musée Géologique de Rennes. (Notice.) *From Joseph Prestwich, Esq., F.R.S.*

Maw, H. L. Letter on the Irish Land Bill. 1870.

Mayer, C. Tableau synchronistique des Terrains Tertiaires inférieurs. 4th edition. Zürich, 1869.

Mayer, K. von. Ueber die Nummuliten-Gebilde Ober-Italiens. 8vo.

Newberry, J. S. The Surface Geology of the Basin of the Great Lakes and the Valley of the Mississippi. 8vo. 1869.

Pettersen, Karl. Geologiske Undersogelser i Tromsö Omegn i Aarene 1865–67. 8vo. Throndhjem, 1868. *From the Royal Norwegian University in Christiania.*

Queensland, Reports of the Geological Survey of. (5.) *From the Survey.*

Ramsay, A. Supplement to the English Cyclopædia: Natural History. Parts 7–9. 1869–70.

Raynolds, W. F. Report on the Exploration of the Yellowstone River. 8vo. Washington, 1868. *From the United States Government.*

Report of the Mining Surveyors and Registrars of Victoria, 30th September, 1869. *From R. B. Smyth, Esq., F.G.S.*

Rigaux, E., et E. Sauvage. Description de quelques espèces nouvelles de l'Etage Bathonien du Bas-Boulonnais. 8vo. 1868. *From W. Whitaker, Esq., F.G.S.*

Sars, G. O. Beretning om en i Sommeren 1865 foretagen zoologisk Reise ved Kysterne af Christianias og Christiansands Stifter. 8vo. Christiania, 1866. *From the Royal Norwegian University in Christiania.*

——. Fortsatte Bemærkninger over det dyriske Livs Udbredning i Havets Dybder. 8vo. 1868. *From the Society of Science in Christiania.*

Sars, G. O. Geologiske og Zoologiske Iagttagelser, anstillede paa en Rese i en Deel af Trondhjems Stift i Sommeren 1862. 8vo. Christiania, 1863. *From the Royal Norwegian University in Christiania.*

Seeley, H. G. Index to the Fossil Remains of Aves, Ornithosauria, and Reptilia, from the Secondary system of Strata, arranged in the Woodwardian Museum. 8vo. Cambridge, 1869.

Sexe, S. A. Le Glacier de Boium en Juillet 1868. 4to. Christiania, 1869 (3 copies). *From the Royal Norwegian University in Christiania.*

Tate, R. The Fuller's-earth in the South-west of England. 8vo. 1870.

Trutat et Cartailhac, MM. Matériaux pour l'histoire primitive et naturelle de l'Homme. 5e Année, Nos. 11 & 12; and 6e Année, No. 1.

Walther, C. F. Jubilæum Eichwaldi. 8vo. Petropoli, 1869.

Whitaker, W. On the Connexion of the Geological Structure and the Physical Features of the South-east of England with the Consumption Death-rate. 8vo. 1869.

Whitley, N. Map of Lundy Island, geologically coloured.

IV. BOOKS PURCHASED FOR THE LIBRARY.

Berendt, G. Geologie des Kurischen Haffes und seiner Umgebung zugleich als Erläuterung zu Section 2., 3. und 4. der geologischen Karte von Preussen. 4to. Königsberg, 1869.

Favre, E. Description des Mollusques Fossiles de la Craie des Environs de Lemberg en Galicie. 4to. Genève et Bâle, 1869.

Hochstetter, F. von. Leitfaden der beschreibenden Krystallographie. 8vo. Wien, 1868.

Kenngott, A. Elemente der Petrographie, zum Gebrauche bei Vorlesungen und zum Selbststudium bearbeitet. 8vo. Leipzig, 1868.

Loriol, P. de, et V. Gilliéron. Monographie Paléontologique et Stratigraphique de l'Étage Urgonien Inférieur du Landeron (Canton de Neuchâtel). 4to. Bâle et Genève, 1869.

Montagna, C. Nouvelle Théorie du Métamorphisme des Roches fondée sur les Phénomènes de Fossilisation des Animaux et des Plantes de tous les âges géologiques. 8vo. Naples, 1869.

Paléontologie Française. Terrain Jurassique. Livraison 19. 1870.

Pictet, F. J. Matériaux pour la Paléontologie Suisse. Série v. Livr. 4 et 5. 1869.

Pictet et Humbert. Mémoire sur les Animaux vertébrés du Terrain sidérolithique du Canton de Vaud. Supplément.

Weiss, C. E. Fossile Flora der jüngsten Steinkohlenformation und des Rothliegenden im Saar-Rhein-Gebiete. Erstes Heft. 4to. Bonn, 1869.

Zirkel, F. Untersuchungen über die mikroskopische Zusammensetzung und Structur der Basaltgesteine. 8vo. Bonn, 1870.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

LITHOLOGY *of the* SEAS *of the* OLD WORLD. By M. DELESSE*.

A STUDY of the deposits which are forming in the bed of existing seas presents great geological interest; for it enables us to restore in imagination the seas of former epochs, and from the present to acquire a knowledge of the past history of our globe.

The larger portions of the seas of the Old World have been explored by numerous soundings, which give their depth as well as the nature of their bed; consequently I have been able to extend in them the researches in lithology which I first commenced in the seas round the shores of France†. The method which I have followed is the same as that at first employed, and the results obtained are embodied in a map which has been recently laid before the Geological Society of London.

Starting from the data furnished by the soundings of the hydrographic engineers, the submarine orography has been laid down by the aid of contour lines, and according to the method of Buache. Then I have endeavoured to separate as much as possible the rocks of the existing period from those of former periods. The first consist almost exclusively of unconsolidated (*meubles*) deposits; whilst the rocks already consolidated do not receive sedimentary deposits, and belong to the second series. The same tints have been given to all rocks which present the same lithological character, without reference to their age. It becomes, therefore, very easy to see how they are disposed over the vast surfaces which extend at the bottom of the seas, and to recognize the order of their distribution: it even becomes possible to recognize the geological relations which connect the existing deposits and submarine rocks with the strata which emerge in their neighbourhood. Let us recapitulate briefly the principal results obtained in some seas of the Old World.

The Sea of Aral is of special interest, since it has been well studied by the Russian Navy, and because it offers at the present time the example of a great lake of salt-water. Its depth is slight; for its bed is the continuation of the surface of the steppes which

* Extract of a work in course of publication by Eugène Lacroix, Paris.

† "Mers de France et Mers Britanniques," Comptes Rendus, April 1867 & 1868.

surround it; it is especially much less than that of the small lakes which are embosomed in mountains, such as the Alpine lakes. The sand forms a margin along the shore: this margin becomes especially wide on the eastern coast, which is low, and receives the principal watercourses. But two-thirds of the bed of the Sea of Aral is formed of mud, which fills those deepest parts in which the movement of the waters is necessarily less felt. It is only on the eastern shore that the Mollusca have been developed in any abundance, and on bottoms of sand having less than 25 metres of water. In the Sea of Aral one can well see how irregular their distribution may be.

The Caspian presents the example of an inland and brackish sea; like the Sea of Aral, it has been thoroughly explored by the Russian navy. Its depth is in relation to the height of its shores; thus in the northern part it becomes remarkably shallow on account of the steppes which surround it, and of the powerful rivers, such as the Volga, which tend incessantly to silt it up. These rivers flow over strata which are eminently sandy, such as the Permian and the Trias, so that they deposit sand over this northern portion; it may be estimated that half of the bed of the Caspian is covered by sand. Mud is deposited in the south, which is the deepest part of this sea. The Mollusca of the Caspian are developed in zones, which recede from the mouth of the rivers, or may even be interrupted; they abound especially on the bottoms of sand, and are rarely found below a depth of 50 metres.

But little is yet known regarding the Black Sea. With respect to its orography, it may be observed that it is funnel-shaped, and at the same time that its southern portion is the deepest and most abrupt. Sand occupies only a small surface; at the same time, on the north-west, where the Black Sea receives the Danube and other great rivers, sand has accumulated along the shore, forming a zone which attains a width of 60 kilometres. Shell-beds occur in it but rarely, and this must be attributed to the fact that the waters are only slightly salt, and the shore generally steep. These deposits, besides, are at a distance from the mouths of the rivers, and occur especially on bottoms of sand.

The Mediterranean presents two great regions, which are separated by Italy, Sicily, and the shallows which connect the latter with the coast of Tunis. Its eastern region is the most extensive and the deepest. As in the preceding seas, it is towards the south that its depth is greatest, while, on the contrary, it is very shallow in the Adriatic.

Mud occupies the greater part of the bed of the Mediterranean, a circumstance which is easily explained, this sea not being subject to tides, and its basin being of great depth.

Sand generally forms a margin along the shores; but it disappears, or becomes rudimentary at the foot of the mountainous coasts. At the mouth of the Ebro, the Rhone, the Po, and the Nile these deposits, on the contrary, cover extensive surfaces. Sand surrounds the islands, especially Corsica, Sardinia, Cyprus, and the Baleares. It attains an exceptional development on the coast which borders the states of Tunis and Tripoli: in fact this shore inclines

gradually under the sea, forming a vast terrace, which is covered with sand; this is notably the case in the Gulf of Gabès, where the sand extends to a distance of more than 200 kilometres from the shore.

In the Mediterranean, certain submarine rocks reappear in the neighbourhood of the coasts, particularly when these are mountainous. Clay extends over large surfaces in the archipelago, in the Gulf of Syrte, in the south and to the east of Malta, in the Adriatic, round Italy, round the Baleares, and to the east of Spain.

Although the Mediterranean contains a great abundance of mollusks, the deposits rich in shell-remains do not cover vast surfaces,—a circumstance which is apparently due to the fact of its shores being generally steep.

The Baltic is an inland sea, very shallow when compared with the seas of the south of Europe. Submarine rocks constitute a large portion of the bed of the Baltic, especially along the coasts of Sweden and Finland, as well as in the Gulf of Livonia. In the archipelago of Aland they even show a connexion with the granitic rocks which form the promontories of Stockholm and Finland. Clay occurs in nearly all the eastern Baltic, and it even extends over large surfaces there. It must no doubt be attributed to the argillaceous beds of the schistose Silurian series; for this formation is strongly developed on the neighbouring shores, more especially in Sweden and Russia. Pebbles also form interrupted zones, which appear to range nearly parallel to the coast of Sweden; their mean depth is about 50 metres, but towards the north it is much greater, so that the sea cannot now displace them. They indicate, therefore, an unconsolidated deposit anterior to the existing epoch, and probably an ancient beach of the Baltic.

Silt fills up several distinct basins; it follows at some distance the indentations of the coast-line, and again recedes round the islands. It fills up the central portions of the Baltic and of the Gulf of Bothnia, but not always the deepest parts.

Sand forms large margins on the shores of the Baltic; it occupies also vast submarine surfaces, particularly off the coasts of Pomerania and Courland, in the Gulfs of Livonia and Finland, in the archipelago of Aland, and in the Gulf of Bothnia. The abundance of sand in the Baltic may be attributed to the circumstance that this sea is not deep, and that it receives numerous torrential rivers which are frequently swollen by melting snows, descending from Finland or the Scandinavian Alps after having swept over granitic rocks; it is owing especially to the fact that the rivers of Scandinavia, Russia, and the north of Germany descending into the Baltic flow through hydrographic basins covered by the diluvium of the north of Europe, which is essentially sandy. Mollusca are rare in the Baltic on account of the very slight saltness of its waters.

Let us now pass to the ocean, leaving the seas of France and of the British Isles, which have been previously studied.

The ocean is of great depth along the Iberian peninsula, and at a short distance from its banks. Submarine rocks indicate the con-

tinuation of those which form the coast. The peninsula is, besides, contoured by a flat shore of sand of small extent, succeeded by mud, which becomes very calcareous at great depths.

In the North Sea, as well as in the glacial ocean, submarine rocks border the fiords and the archipelagos of Norway and Lapland. Very extensive zones of clay extend along one part of Norway, and must doubtless be attributed to the cropping out of palæozoic schists. Besides, as is usual, the ocean adjoining the peninsula of Scandinavia essentially exhibits a bed of sand; mud reappears again, especially in the neighbourhood of argillaceous rocks, and in that case may probably be derived from their destruction.

The White Sea also exhibits an inland sea, connected by a wide strait with the glacial ocean. The most striking feature of its orography is a depth very much greater in its north-eastern portion and in the Gulf of Kandalaks than in its centre and the part nearest the ocean. The long Gulfs of the Dwina and of Kandalaks are placed the one upon the line of the other, and correspond with an important submarine depression, which is very strongly marked and parallel with the Dwina, as also with the principal rivers of these regions.

Soundings have shown the presence of rocks near the shores of the White Sea, particularly at its opening in the Gulf of Mezen, and also in the Gulf of Onega: these rocks even indicate a connexion of the peninsula of Lapland with the continent.

Sand covers vast surfaces at the entrance of the glacial ocean, but in the White Sea it only borders the shores, and silt or mud almost entirely covers over the bed. The extent of silt is doubtless due to the circumstance that the White Sea, by reason of its orography, plays the part of a settling-basin to the troubled waters that it receives in great abundance, especially at the time of melting of the snows; it is also attributable to the fact that the ice which covers it during one portion of the year also contributes to facilitate the deposition of the silt. Shell-bearing beds are very limited in the White Sea, probably on account of the fresh and muddy waters which pour into it; they, however, occur abundantly on the sands at the entrance to the glacial ocean. Hence it is to be seen that the mollusca multiply and also attain great development in very northern latitudes, and as far as within the Polar circle.

A study of the inland seas of the Old World reveals general and very striking characters both in their orography and lithology. First, their depth northwards is slight, and increases towards the south; besides, the principal rivers empty themselves more especially on their northern sides. These features occur markedly in the Caspian Sea, the Persian Gulf, the Sea of Azof, the Black Sea, the Baltic, the Adriatic, and finally in the Mediterranean.

The Baltic, the Caspian, and the Adriatic present striking analogies; for all three are less salt than the ocean: they receive a multitude of rivers and of streams, which transport a quantity of débris and tend to fill their basins; they are especially remarkable by the great extent of their sandy deposits.

The Black Sea, the Mediterranean, and White Sea exhibit, on the contrary, lithological characters entirely different; since mud or silt predominates, and the sandy deposits are there reduced to a small extent. [J. P.]

On Fossil Typhaceæ. By Prof. F. Unger.

[Proc. Imp. Acad. Vienna, January 7, 1870.]

The existence of representatives of the genera *Typha* and *Sparganium* in Tertiary deposits has been but lately ascertained, and many remains of the former genus are probably still regarded as species of *Arundo*. A species of *Typha*, first discovered by M. D. Stur, is widely diffused. Certain vegetable forms found in the Gosau Sandstones of Gams, in Styria, possibly represent the prototype of all the *Typhæ* of subsequent periods. At present three species of *Typha* and six of *Sparganium* are known to exist in a fossil state. [Count M.]

On Devonian Entomostraca. By M. P. Richter.

[Zeitschr. deutsch. geol. Gesellsch. 1869, p. 75.]

M. Richter has described the Entomostraca contained in the Devonian strata of Thuringia. The uppermost horizon, in which fossil Entomostraca are very abundant, is perfectly analogous to the *Cypridina*-shales of the Harz and of Nassau. In the second horizon they are far less abundant, and in the lowest no trace of them has been detected. The author describes and figures eleven species of *Cypridina* (six new), three of *Beyrichia* (all new), and two of *Cytherina* (one new). He regards the oval individuals of *Cypridina* as males, and the more spherical forms as females. [Count M.]

On the Cephalopoda *from the* Oolite *of* Balin, *near* Cracovia. By Dr. M. Neumayr.

[Proc. Imp. Geol. Inst. Vienna, December 21, 1869.]

Dr. Neumayr publishes a list of the Cephalopoda from the Oolitic beds of Balin, from which it appears that the *Macrocephalus*- and *Aspidioides*-zones are best represented, and next to these the *Anceps*- and *Athleta*-zones, so that the Cephalopodous fauna of Balin may be regarded as corresponding to those of the Great Oolite above the Fuller's Earth in England, of the "Callovien" in France, and of the upper horizon of the *Dentalium*- and *Ornatus*-clays, and of the *Macrocephalus*-oolite of Würtemberg. *Amaltheus* (*Amm.*) *Lamberti*, which constantly occurs above the *Ornatus*-clay, has not yet been found, nor have any traces of species of more recent date. The only representative of a deeper horizon is a fragment of an Ammonite, very nearly allied to but not identical with *Stephanoceras bifurcatum*, Ziet., of the *Parkinsoni*-zone. This fragment may prove, on closer examination, to be an inner whorl of a species belonging to the group of *Cosmoceras calloviense*, *C. Gowerianum*, &c., which, in

young individuals, are not easily distinguishable from *Stephanoceras bifurcatum*, *S. subfurcatum*, &c. The author's general results are essentially identical with the conclusions arrived at by MM. Falloux and Waagen, but by no means in accordance with those to which Dr. Laube was led by the study of the Echinoderms, Lamellibranchiata, and Gasteropoda.

In the following list of species found at Balin, the zones to which the species belong are indicated by abbreviations as follows:—

Park. = zone of *Stephanoceras Parkinsoni.*
Fer. = zone of *Stephanoceras ferrugineum* (Fuller's Earth).
Asp. = zone of *Oppelia aspidioides.*
Macr. = zone of *Stephanoceras macrocephalus.*
Anc. = zone of *Perisphinctes anceps.*
Athl. = zone of *Aspidoceras athleta.*
Lamb. = zone of *Amaltheus Lamberti.*

List of the Oolitic Cephalopoda of Balin.

Belemnites Beyrichi, *Oppel.* Asp.
—— calloviensis, *Oppel.* Anc.
—— subhastatus, *Zieten.* Macr.
—— hastatus, *Blainv.* Athl. and higher strata.
—— bzoviensis, *Zeuschner.*
—— Waageni, n. sp.
Nautilus subtruncatus, *Morr. & Lyc.* Asp.
—— calloviensis, *Oppel.* Anc.
Rhynchotheutis Süssi, n. sp.
Amaltheus Lamberti, *Sow.* Lamb.
—— funiferus, *Phill.* Macr.
Harpoceras discus, *Sow.* Asp.
—— hecticum, *Reinecke.* Macr.
—— punctatum, *Stahl.* Anc.
—— Brighti, *Pratt.* Athl.
—— lunula, *Zieten.* Anc.
—— krakoviense, n. sp.
Oppelia aspidioides, *Oppel.* Asp.
—— latelobata, *Waag.*
—— cf. biflexuosa, *D'Orb.* Asp.
—— subcostaria, *Opp.* Macr.
—— n. sp., aff. psilodisco, *Schlönb.*
Œcotraustes conjungens, *Mayer.* Macr.
—— serrigerus, *Waagen.* Asp.
Stephanoceras coronatum, *Brug.* Anc.
—— Julii, *D'Orb.* Fer.? Asp.?
—— contrarium, *D'Orb.* Fer? Asp.
—— cf. bifurcatum, *Zieten.* Park.
—— Herveyi, *Sow.* Macr.
Stephanoceras tumidum, *Rein.* Macr.
—— macrocephalum, *Schloth.* Macr.
—— sublæve, *Sow.* Macr.
—— microstoma, *D'Orb.* Macr.
—— bombur, *Oppel.* Macr.
Cosmoceras ornatum, *Schloth.* Athl.
—— Jason, *Rein.* Anc.
—— Duncani, *Sow.* Anc.? Athl.?
—— Torricellii, *Opp.* Macr.
—— cf. Keppleri, *Opp.* Macr.
Perisphinctes procerus, *Sieb.* Fer. Asp.
—— Moorei, *Opp.* Asp.
—— funatus, *Opp.* Macr.
—— aurigerus, *Opp.* Fer. Asp.
—— curvicosta, *Opp.* Anc.
—— sulciferus, *Opp.* Athl.
—— Orion, *Opp.* Athl.
—— Königi, *Sow.* Macr.
—— Wagneri, *Opp.* Asp.
—— patina, n. sp. Macr.
—— euryptychus, n. sp. Athl.
—— evolutus, n. sp.
—— furcula, n. sp.
—— bracteatus, n. sp.
—— subcontractus, *Morr. & Lyc.* Asp.
—— anceps, *Rein.* Anc.
Aspidoceras athleta, *Phill.* Athl.
—— annulare, *Rein.* Athl.
—— Fuchsi, n. sp.
Ancyloceras calloviense, *Morr.* Macr.

[COUNT M.]

On the OCNIAN (TRIAS), DOGGER, *and* LIAS LIMESTONE *of the* BATHONY FOREST (S. W. HUNGARY). By Dr. E. VON MOJSISOVICS and M. VON HANTKEN.

[Proc. Imp. Geol. Inst. Vienna, December 21, 1869, and February 15, 1870.]

THE probably older horizon of these Ocnian strata is represented

by an alternation of hydraulic marls and bituminous dolomites and limestones, characterized by the presence of a new species of *Trachyceras, Tr. Attila,* Mojs. The reddish-grey limestones of the upper horizon are equivalent to the "Pötschen" Limestones of the North and to the "Buchenstein" Limestones of the South Alps. The most frequent fossil forms in them are *Ammonites* (*Arcestes*) *tridentinus,* Mojs., sp. n., *Am. Arpadis,* Mojs. sp. n., and *Halobia Lommeli,* Wissm. *Trachyceras Attila* is of rare occurrence, as also in the "Pötschen" Limestones. *Am.* (*Arc.*) *tridentinus,* the most frequent form in the Bakonyan Limestone, as also in the "Pötschen" and "Buchenstein" Limestones, was first made known as of very rare occurrence in the Ocnian porphyritic Tuffs of the South Alps, characterized by the presence of *Trachyceras doleriticum* and *T. Archelaus.* The Bakonyan Limestones, with *Am.* (*Arc.*) *tridentinus,* are locally overlain by green tuffs. A ravine close to the marble-quarry of Csennye proved an abundant locality for Ammonites characteristic of the Inferior "Dogger," such as *Am. Murchisonæ,* Sow., *Am. fallax,* Ben., *Am. scissus,* Ben., *Am.* cf. *tatricus,* Pusch, *Am.* cf. *gonionotus.* They are found mixed with *Am. silesiacus,* Opp., and *Am. serus,* Opp., from the Lias of the neighbouring quarry, and with an abundance of *Fimbriati* of at least two different species. A well-preserved specimen of *Am. superbus,* B., has been obtained from Somhegy. A bed of Liassic Limestone includes an enormous quantity of Brachiopods, among which *Terebratula Aspasia,* Men., predominates, but very few Ammonites.

On the Structure *of the* Spiral Shell *of* Cephalopods. By Prof. E. Suess.

[Proc. Imp. Acad. Vienna, March 10, 1870.]

Dr. Carpenter first stated that the shell of *Nautilus Pompilius* consists of two strata, an outer testaceous one (the "ostracum"), and an inner one, of the nature and aspect of mother-of-pearl. The same is the case with the shell of *Argonauta* and of the Ammonites, the mother-of-pearl stratum constituting the septa of the chambers. *Arcestes, Goniatites, Phylloceras,* and *Clymenia* have besides a *rugose* stratum, rather answering to an imperfect formation of mother-of-pearl than the black stratum of *Nautilus.* In the above-named genera, the periodical constrictions take place under the form of *varices,* and in the rest of the *Ammonitidæ* in the form of *contractions* of the shell. Taken as a whole, the more ancient forms possess generally *one* chamber, including the whole animal, and really inhabited by it, while many of the comparatively more recent forms adhered only by muscular prolongations of the hind portions of their body, the other chambers serving only as an hydrostatical apparatus by whose aid the animals moved with more ease through the sea. The shell of the female *Argonauta,* provided with rudimentary shell-muscles, represents a *rudimentary* Ammonite shell, an "ostracum" without stratum of mother-of-pearl. *Argonauta* is a member of an

extensive family, beginning with *Trachyceras* and comprehending the genera *Cosmoceras*, *Toxoceras*, *Crioceras*, the *Flexuosi*, and a good number of Scaphites.

On Living *and* Fossil Algæ. By Dr. A. Boué.

[Proc. Imp. Geol. Inst. Vienna, January 18, 1870.]

The living *Algæ* consist of a *stem*, more or less thick, and often of considerable thickness in large species, and of a *foliage* very diversified in quantity, length, and thickness. The movement of the waves, or any other external action, may compress or distort the wing-like leaves of certain *Algæ*, and thus give rise to indistinct, partly torn, or extended forms, such as are occasionally met with in Eocene *Carpathian Sandstones*. The round and oval forms conspicuous on some specimens may be somewhat flattened, and thus apparently enlarged, *fructifications*, as they appear occasionally nearly isolated on some stems, the foliage having been nearly destroyed. Possibly the fragments and impressions not rarely occurring in fucoid shales and Eocene sandstones, and generally ascribed to Monocotyledones, may be fragments of species of the genus *Zostera*, one species of which is constantly associated with Algæ in the northern seas. Their very large and rather slender portions float in the water like those of the Fuci; they are easily torn and divided, and have some analogy in structure with the lengthened and undetermined fragments in fucoid deposits. *Zosterites* is known to occur in Eocene deposits, and such marine plants may more probably be found associated with Algæ than any land plants. If the above-mentioned impressions were really those of Monocotyledons, those of many other terrestrial genera might be expected to be found associated with them.

On Cœlacanthus. By Dr. von Willemoos-Suhm.

[Proc. Imp. Geol. Inst. Vienna, December 18, 1869.]

Dr. von Willemoos-Suhm has published (Palæontographica, xvii. 1869) a monograph of *Cœlacanthus* and some genera closely allied to it. The species described are *C. macrocephalus*, sp. n., *C. Hassiæ*, Münst., *C. (Undina) minutus*, Wagner, *C. penicillatus*, Münst., and *C. major*, Wagner, all from the copper-shales and from the shales of Solenhofen and Cirin. There is no generic difference between the species from the copper-shales and those (*Undina*) from the Lithographic shales, closer examination having proved these latter (*C. macrocephalus* and *C. Hassiæ*) to possess the characteristic deep fissure of the pectoral fin, the ossified swimming-bladder, and the articulation of the unpaired fins on bifurcated plates. The author unites with *Cœlacanthus* the genus *Graphiurus*, Kner, from the Raibl shales, and refutes the generic claims of *Macropoma*, Agassiz.

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

April 27th, 1870.

Robert Logan Jack, Esq., of the Geological Survey of Scotland; George Alexander Lebour, Esq., of the Geological Survey of England and Wales; Coles Child, Esq., of the Palace, Bromley, S.E., and Harry Rivington, Esq., 22 Finsbury Square, N., were elected Fellows of the Society; and Prof. Joseph Szabo, of Pesth, was elected a Foreign Correspondent.

The following communications were read:—

1. *On the* Species *of* Rhinoceros *whose* Remains *were found in a* Fissure-cavern *at* Oreston *in* 1816. By George Busk, F.R.S., F.G.S.

In the year 1816, during the course of the quarrying of the limestone-rock at Oreston for the construction of the Plymouth Breakwater, a cavernous fissure was opened, containing numerous more or less fragmentary remains of *Rhinoceros*, but none of any other animal.

Notice of this discovery was given by Mr. Whidbey, the engineer of the works, to Sir Joseph Banks, at whose instance the bones were submitted to Sir Everard Home for examination, by whom a short paper on the subject was communicated to the Royal Society, which was published in the 'Philosophical Transactions' for 1817.

This paper contains little more than a mere enumeration of the bones and teeth, which are all assigned to *Rhinoceros*; and it was considered probable by Sir Everard Home that they belonged to three individuals.

In 1821 several other cavities in the limestone, of the same kind, were encountered, in one of which, amongst other mammalian remains, chiefly of Bear, a single tooth of *Rhinoceros* was met with, "lying apart from the rest;" this is described by Sir E. Home as the "fourth grinder from the front, right side, of the Single-horned Rhinoceros."

The above appear to have been the only Rhinocerine remains discovered at Oreston; for, although in 1823 a further set of caverns was laid open, whose contents have been ably described by Mr. Clift in the 'Philosophical Transactions' for 1824, nothing belonging to *Rhinoceros* was there found *.

The specimens enumerated by Sir E. Home are about twenty-two in number; but this cannot have included all that were sent by Mr. Whidbey, since the number of specimens assigned to the locality in the Catalogue of the Museum of the Royal College of Surgeons, where they are deposited, is thirty-eight or thirty-nine. They are numbered from 877 to 916. The tooth mentioned by Sir E. Home as having been found in the second cavern does not appear to be among them; and one of the numbered specimens (897) is not at present forthcoming.

As regards condition and colour, with one or two exceptions, the specimens have a very uniform aspect; and it is highly probable that Professor Owen is right in assigning them all to a single individual.

Sir E. Home imagined that the glenoid cavity of the scapula was too small in proportion to the head of the corresponding humerus, and that a detached olecranon belonged to a still smaller individual. But as regards the scapula in question, there does not appear to be any reason to concur in this suggestion; and as I have been unable to find the detached olecranon, I can offer no opinion respecting it. Most of the other epiphyses of the larger long bones are detached, which is in favour of the supposition that the ulna may have formed part of the same skeleton, of an individual which had not attained to full maturity.

It should be observed, however, on the point of age, that the complete union of the distal epiphysis of the humerus and of that of the metacarpals, and the much worn condition of the teeth, show that the animal must have reached pretty nearly its full stature; and if the rate of the development of the bones was the same as in the Elephant, it was probably somewhere about twenty years old. It must be confessed, however, that the teeth, for some reason, appear to be rather unduly worn for that age.

Sir Everard Home, as might be expected from the period at which he wrote, made no attempt to discriminate the species to which the remains belonged, unless we may interpret his expression respecting the tooth found in the second cavern as implying that he regarded them as belonging to *Rhinoceros unicornis*. Nor does Cuvier, when referring to Sir Everard Home's paper, make any remark on this point.

* In 'British Fossil Mammals' (p. 343), it is stated, with reference to the Rhinoceros-bones, that most of the parts recovered from this cavern were determined by Mr. Clift. But this does not appear to be the case. The remains described, and so beautifully figured by Mr. Clift, are those which occurred in the third set of caverns in the year 1823, and which, as above stated, did not afford any Rhinocerine remains. The bones forwarded to Sir Joseph Banks were "determined" by Sir Everard Home, and not by Mr. Clift.

In the 'Catalogue of Fossil Mammalia,' however, they are assigned to *Rhinoceros tichorhinus*; and Professor Owen, in 'British Fossil Mammals' (p. 343), notices and partially describes them under the head of that species, with which, in fact, they appear to have been associated by all palæontologists who have since had occasion to refer to them, with the exception of Dr. Falconer, who seems to have fully recognized the non-tichorhine character, at any rate, of the teeth. But he has left no remarks respecting the other bones *.

It nevertheless appears to me abundantly clear that neither the teeth nor the bones present any tichorhine character, but, on the contrary, that they are plainly referable to the widely different great southern form, *R. leptorhinus*, Cuv. (*R. megarhinus*, Christ.†).

The Oreston collection therefore acquires very great interset, not only as adding another to the as yet scanty instances of the occurrence of that species anywhere in Britain, but more especially as affording the only recorded example of its discovery in a cavern of any kind—a fact the more remarkable, perhaps, since no vestige of its remains has occurred in the Brixham cave, nor has as yet, I believe, been detected in Kent's Hole, where, more particularly, we might have expected to meet with an associate of the *Drepanodon*.

I will now proceed to state the proofs which appear to me calculated to support the conclusion at which I have arrived.

* It is only since my attention was lately directed to these remains, that I noticed a brief remark extracted from one of his note-books, and given in his invaluable 'Palæontographical Memoirs' (vol. ii. p. 353), which shows that his acute and practised eye had long ago (1859) discerned the distinction between the Oreston teeth and those of *R. tichorhinus*. His words are, "they are quite unlike *R. tichorhinus*; and I believe they agree with *R. hemitœchus*."

Although unable, for reasons herein assigned, to agree with my lamented friend in the latter supposition, it was very satisfactory to find that my own opinion regarding the non-tichorhine relations of the teeth was supported by his eminent authority.

† It is to be hoped that the long-standing dispute about the proper appellation of this species, may now be considered finally settled. M. Christol's mistaken interpretation of the figures of Cortesi's skull has been fully explained and satisfactorily refuted. The identity, also, of that skull with the three so-called megarhine skulls that have at different times been disinterred near Montpellier has, as it seems to me, been completely established by the direct personal examination and comparison of them by Dr. Falconer; and it is, I believe, admitted by all, or nearly all, living palæontologists. The question therefore appears to require no further discussion. I would, however, take this opportunity of noticing a curious point connected with it, which seems to have been strangely overlooked by all who have written upon it except M. Duvernoy. It is nevertheless a point which, if properly considered, must long since have settled any dispute.

In 1854 M. Duvernoy pointed out the palpable fact that, supposing the Cortesi skull to have been furnished, as was imagined, with a septum, that septum, as shown in the figures where it was supposed to be represented, must have been placed precisely where it should not have been had the skull been that of *R. hemitœchus*. In that species, as is well known, the septum terminates a few inches from the extremity of the nasals. Now this part is entirely wanting in the Cortesi cranium, in which the supposed remains of the septum are placed as far back as in *R. tichorhinus*. In fact, they retreat quite out of sight; and it is this circumstance probably that may have led M. Christol for some time to regard the skull as that of *R. tichorhinus*.

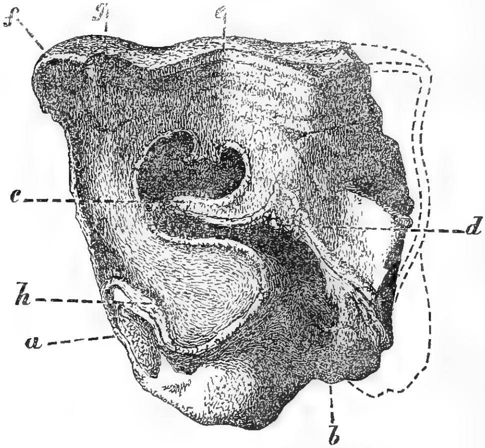
Most of the specimens are much broken, and consequently but ill fitted, more especially in the case of the genus *Rhinoceros*, for the determination of specific characters; but amongst them are several which will amply suffice for the purpose; and it is to these only therefore that I shall confine what I have to remark.

1. *The Teeth.*

The collection, as it exists in the College Museum, includes six molars—three maxillary, and three mandibular. Of the former, two, though much injured, are sufficiently perfect to afford good characters, the third is too imperfect to be of any use.

The most characteristic teeth are the two upper molars (numbered 877 and 878); and they are clearly the opposite teeth of the

Fig. 1.—*Left Upper Molar of Rhinoceros from Oreston.*

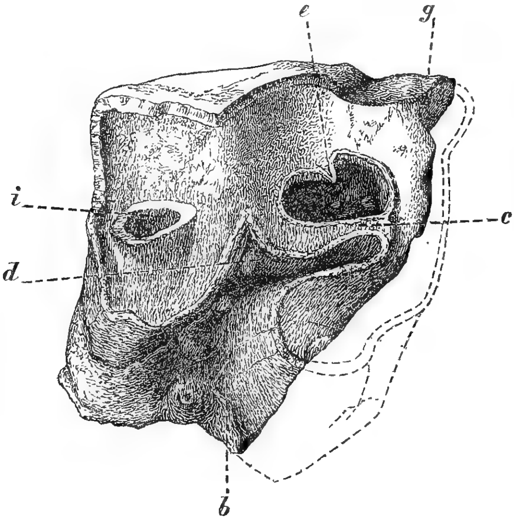


a. Anterior vallum or "guard." *b.* Entrance of median sinus ("anterior valley"). *c.* Uncus ("crochet"). *d.* Columella. *e.* Crista ("anterior combing-plate"). *f.* "First ("anterior" or "angular") costa. *g.* Second costa. *h.* Anterior sinus.

same individual. As to their place in the series, opinions may very probably differ. In the Museum Catalogue they are described as the first molar ($\underline{m\,1}$); and Dr. Falconer, in the note above referred to, also appears to have assigned that position to them. I am myself, however, more inclined to regard them as the second molar ($\underline{m\,2}$), chiefly for the reason that the anterior outer angle is very acute, which shows that the tooth was oblique—and also because the anterior vallum is not prolonged in the form of a cingulum on the internal face of the anterior column, which it most usually is, but not always, in the $\underline{m\,1}$ of *R. leptorhinus*. And in all species of

Rhinoceros that tooth is usually much more rectangular than m 2. Moreover, on comparison, these teeth will, I think, be found to agree more closely with the m 2, of which a figure is given by Mr. W. Boyd Dawkins in his paper on the dentition of *R. leptorhinus*

Fig. 2.—*Right Upper Molar of Rhinoceros from Oreston.*



i. Remains of posterior sinus.
(*Other letters the same as in Fig.* 1.)

(*R. megarhinus*, B. D.) in the 'Natural History Review' (vol. v. p. 409), than with the m 1 there represented. The point, however, is not one of any great importance.

Both the teeth, as before remarked, are much worn—the remaining height of the crown from the root of the fangs, measured on the dorsum, being about 2 inches. In the specimen, no. 878 (Fig. 1), which is of the left side, the anterior column is entire, and the remains of the very oblique and strongly developed anterior vallum or "guard," *a*, can be seen on its anterior face only, not encroaching at all upon the internal face. The entrance of the median sinus ("anterior valley"), *b*, presents two rather strong conical papillæ or cusps, whose points are slightly worn. The hinder part of the tooth, including the greater portion of the posterior column, is broken off. The uncus ("crochet"), *c*, is long, tapering, and curved outwards, so that its point is directed towards the anterior outer angle of the tooth. So far as it is worn down, and for a short distance beyond the worn surface, the uncus is free; but at a greater depth it is joined to the anterior column by a narrow isthmus, so

that at the bottom a portion of the sinus is isolated. The uncus arises from the posterior column at a very acute angle; but owing to its rapidly making a curve outwards, its general direction is nearly parallel with that of the column; and the short reentering angle is occupied by a slender columella, *d*, rising from the bottom of the sinus. A short crista (" anterior combing-plate"), *e*, projects into the sinus on its outer side, and in a line nearly vertical to the uncus, with which, however, it is in no way connected. What remains of the dorsum or " outer lamina" shows no elevation of the first or angular costa (*f*), but a considerable elevation of the second (*g*); the remainder of the surface is evenly undulated, without any distinct indication of a fourth costa. The anterior column is widely expanded at its inner end, with a rather deep sinuosity on its anterior aspect (*h*). The enamel throughout is very thin, and where the surface is exposed it is smooth. Towards the base of the dorsum there is a thin irregular coating of cementum.

In the opposite tooth, no. 877 (Fig. 2), we are fortunately furnished with exactly the parts that are wanting in no. 878, viz. the posterior column, &c. The tooth is so much worn that the posterior sinus (" valley") is represented merely by a small circular pit (*i*): it is consequently impossible to ascertain whether the hinder vallum ("third collis") was cuspidate or emarginate. In all other respects the tooth presents exactly the same characters as its opposite fellow, except that the entrance of the median sinus is furnished with only a single cusp, and that, owing to its being rather more worn, the uncus extends quite across the sinus, and becomes confluent with the anterior column, so as completely to isolate the external portion of the sinus, and produce a third pit or fossette. But it will be observed that this fossette is not formed in the same way as the peculiar " tichorhine pit" (that is, by the coalition, *ab initio*, of the uncus and crista), but simply, as not unfrequently occurs, by the prolongation at the base of the former, so that it reaches as far as the anterior column—a circumstance obviously of little moment as a character, since, as we here see, it may be said to exist on one side and not on the other. It may also be added that a similar prolongation of the uncus has been previously noticed in teeth of *R. leptorhinus*, an instance of which is afforded in pl. 51. fig. 4 of the 'Ossemens Fossiles,' which plainly represents, as it seems to me, a tooth of *R. leptorhinus*, and not of *R. hemitœchus* as supposed by Prof. Owen. And a similar instance is shown in the tooth figured by Mr. W. B. Dawkins (*l. c.* p. 410, fig. 10), I believe, from Grays Thurrock. And it is important to remark the occasional possible occurrence of this peculiarity, since M. Christol, in his definition of *R. megarhinus*, expressly says, " le crochet de leur colline postérieure ne se joint jamais à l'antérieure" *.

* Dr. Falconer also (*op. cit.* ii. p. 336, pl. xviii. fig. 5) notices and figures a similar occurrence in a molar of *R. hemitœchus*, and remarks:—"That this peculiar confluence of the crochet with the anterior barrel is abnormal in the true molars, is proved by the extreme rarity of the instances which have been observed of it in any species of *Rhinoceros*." He then cites Cuvier's figure, to

As regards dimensions, so far as they can be employed in the distinction of the quaternary species of Rhinoceros, little need be said. It may be broadly stated, at any rate, as regards *R. tichorhinus*, *R. leptorhinus*, and *R. hemitœchus*, that although the leptorhine teeth on the whole are the largest, the differences in this respect are so trifling, and the variations so considerable, that but little reliance can be placed upon deductions drawn from a single tooth; I shall therefore content myself in the present instance with simply giving the dimensions of the Oreston $\underline{m\ 1}$ or $\underline{m\ 2}$.

	in.
Length	2·3
Width at anterior column	2·5
Width at posterior column	2·0

These dimensions, or at any rate the two former, are exactly the same as in three instances recorded by Dr. Falconer, from Lyons, Nice, and Imola—although it is true they are less than in the general run of British specimens in the British Museum, in which the mean of the corresponding dimensions may be taken as 2·6 × 2·5.* But in partial explanation of this, it must be considered that, at the height to which the crown has been reduced in the Oreston specimens, they scarcely afford the full dimensions of the entire tooth.

Lower Teeth.—The two lower molars, to which alone I need refer, are nos. 880 and 881. The former (Fig. 3) is the crown por-

Fig. 3.—*Crown of second Lower Molar of Rhinoceros from Oreston.*

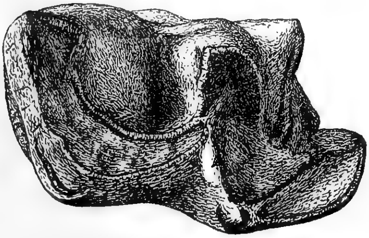
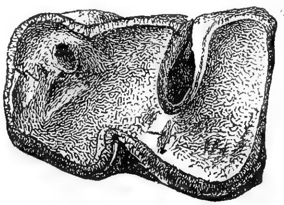


Fig. 4.—*Fourth Lower Premolar of Rhinoceros from Oreston.*



tion of $\underline{m\ 2}$; and, with respect to it, all I would remark is, that the deep excavation of the worn surface, in consequence of which the

which I have adverted, and which he also assigns to *R. leptorhinus*, and further states that he is unacquainted with any other instance of what he terms "a bridge-crochet" in a true molar having been figured, "although," he says, "in the milk-molars it is by no means of rare occurrence." He also remarks that this appearance "must not be confounded with the cohesion between the 'crochet' and the 'combing' plate which gives rise to the third fossette, so characteristic of *R. tichorhinus*" (p. 33).

* It is, perhaps, not improbable that the Oreston teeth may be milk-molars.

points of the hinder horns of each crescent rise into acute eminences, shows a mode of usure totally different from that which is observed in *R. tichorhinus*. Moreover the enamel is far too thin and smooth for that species, nor does the anterior column exhibit on its inner face the distinct posterior costa which exists in the lower molars of *R. tichorhinus*. I am unable to point out any sufficient character by which this particular tooth could be distinguished from that of *R. hemitœchus*. The size of the tooth is—

Length	2·1 inches.
Width..	1·15 and 1·2.

No. 881 (Fig. 4) is so much worn as to be of very little use for the purpose of diagnosis. It appears, as stated in the 'Catalogue,' to be $\overline{pm\ 4}$. That it is not tichorhine is obvious enough from the thinness of the enamel. But, except that it is, perhaps, rather more tapering in front, I do not see how it could be distinguished from the same tooth in *R. hemitœchus* or *R. etruscus*.

These teeth, therefore, except as regards *R. tichorhinus*, are of no value for my present purpose. But with respect to the maxillary teeth, the following characters may be adduced as distinguishing them from those of the tichorine Rhinoceros, and, in some measure, from those of any other species.

1. The thinness and smoothness of the enamel.
2. The configuration of the dorsal surface, as seen in—
   (*a*) The lowness of the *first* and *fifth costæ*—that is to say, of the anterior and posterior angles.
   (*b*) The even undulation of the posterior area, as it is termed by Mr. W. B. Dawkins, and the total absence of the fourth elevation counting from the front, or the fourth costa.
3. The expanded inner end and the pronounced sinuosity on the anterior aspect of the anterior column.
4. The great size of the anterior vallum.
5. The form and connexions of the uncus, and the consequent absence of the true "tichorhine pit."

From the corresponding tooth of *Rhinoceros hemitœchus* the present seems to differ:—

1. In the lowness of the anterior costa, *c* 1, and consequent absence of the deep sulcus between it and the second or principal costa.
2. In the comparatively easy undulation of the rest of the dorsal surface.
3. In the thinness of the enamel and, it might be added, of the cementum—a character upon which, however, I think Dr. Falconer was disposed to lay rather undue weight.
4. In the form of the uncus—which, instead of being thick and rounded towards the point, is slender and attenuated, and instead of pointing directly forwards, as in *R. hemitœchus*, is ultimately directed forwards and outwards *.

* Dr. Falconer, as every one knows, placed great reliance upon the angle formed between the uncus and posterior column in the discrimination of *R.*

5. In the direction of the crista, which, when present in *R. hemitœchus*, arises further back from the outer lamina, or even from the base of the hinder column itself, and projects in a direction nearly parallel with the uncus, instead of at right angles to it.

2. *Other Bones.*

Most of the bones, as I have said, are in a very fragmentary condition; but amongst them are one or two which are capable of affording excellent characters, and are, in fact, alone sufficient, as it seems to me, to determine the species to which they belong.

The first of these is a right middle metacarpal, (no. 905 in the Catalogue). The bone is nearly perfect; and its growth is completed, inasmuch as no trace remains of the junction between the shaft and the epiphysis.

Regarded with respect either to its size or to its form and proportions, this bone differs so strikingly at first sight from the corresponding bone in any other species of Rhinoceros, recent or extinct, with which I am acquainted, that it is surprising its true specific relations should have been so long overlooked. First, as regards its *size*. In Table I. (in which the dimensions and proportions of the middle metacarpal, in several instances, of *R. leptorhinus* and *R. tichorhinus* are given), it will be seen that the Oreston bone is nearly $1\frac{1}{2}$ inch longer than the longest specimen of *R. tichorhinus* of which I have any knowledge, and, in the second place, that it nearly corresponds in length with the metacarpal of *R. leptorhinus*, as shown in two specimens from Grays Thurrock, in the British Museum*. As regards the other dimensions, it will also be seen considerably to exceed those of *R. tichorhinus*—as, for instance, in the size of the two extremities, and especially in the transverse diameter of the distal articular surface or trochlea, which may be regarded as affording a pretty certain term of comparison. With respect to the least circumference of the shaft, it is true that in one instance of *Rhinoceros tichorhinus* that has come under my observation, from the river-gravel at Stratford-on-Avon, the cir-

---

hemitœchus from *R. leptorhinus*; and, in the main, I think he was quite right in so doing. But it must not, so far as I can judge, be supposed that this character affords an invariable criterion in all cases. Several instances, besides the present, showing this, may be cited from the figures given in the 'Palæontographical Memoirs' and elsewhere. For instance, in the lower jaw from Lyons, of which a figure is given in pl. xxxi. fig. 2, the crochet appears to rise very much in the same way as in the Oreston teeth, that is to say, at an acute angle, and then to curve outwards. Again, in Mr. B. Dawkins's fig. 10 (N. Hist. Rev. v. p. 410), the crochet cannot be said to arise at an open angle, but the reverse; and the same may be said of the milk-molar, fig. 4 (*l. c.* p. 405). I have also in my possession a *mm* 3 from Ilford, belonging to Mr. Prestwich, in which the same may be observed; and, further, from this specimen it is apparent that as the tooth wore down, the angle would become more and more open; so that, without throwing any doubt upon the general usefulness of the form of the angle as a diagnostic character, it is, I think, one which requires to be used with caution.

* From the close similarity of these two metacarpals from Grays, it is not improbable they may be the right and left of the same individual.

cumference is greater; but this is owing to the circumstance that that bone appears to be one in which the muscular ridges on the hinder surface are very much developed, and the whole bone unusually thick. The Oreston bone is thus satisfactorily shown to be much larger in every way than that of *R. tichorhinus.*

But this is not all; it is not only much larger, but it differs still more remarkably in its proportions. These are also shown in the Table, in which the last two columns give the ratio, first, of the least circumference to the length of the bone, which I call the "perimetral index"—and, secondly, of the antero-posterior diameter of the shaft at the middle to its transverse diameter at the same point, which ratio I denominate the "latitudinal index." Inspection of the figures in these two columns will show at a glance how much slenderer, and how very much more compressed or flattened, is the metacarpal of *R. leptorhinus* as compared with that of *R. tichorhinus.*

I have not as yet met with the metacarpal of either *R. hemitœchus* or *R. etruscus*; but as its dimensions, and in some measure, probably, its proportions may be pretty safely predicated from those of the corresponding metatarsal, I have subjoined a Table (II.) of the dimensions and proportions of that bone in the four known quaternary species.

From this it will be seen that in *R. leptorhinus* the middle metatarsal is about one-eighth shorter than the corresponding metacarpal, and in *R. tichorhinus* about one-twelfth. Assuming that the proportion between the two bones is the same in *R. hemitœchus* and *R. etruscus*, it follows that the mean length of the metacarpal in those species would be from 7·4 to 7·6; and this is doubtless not far from the truth. It is clear, therefore, that, as regards length, the metarcarpal of *R. leptorhinus* far exceeds that of either of the other three species; and, in fact, it is longer than in any species, living or extinct, except *R. unicornis*, and perhaps *R. simus*, of whose skeleton, however, we have no knowledge. Again it will also be perceived that although the "perimetral index" in *R. hemitœchus* is very nearly the same as in *R. leptorhinus*, the "latitudinal index" is considerably higher, or in the proportion of, perhaps, 417 to 380. This shows how much flatter or more compressed the metacarpal of *R. leptorhinus* is than than that of *R. hemitœchus*, and, as will be seen in the Table, still more strikingly than that of *R. etruscus*, which, to judge from the metatarsal, must be by far the most cylindrical and at the same time the slenderest of all four.

From the above considerations, I think it impossible to avoid the conclusion that the Oreston metacarpal can only belong to *R. leptorhinus.*

The only other bone to which I need refer is that numbered 906. It is the distal extremity, quite perfect, of the right inner metatarsal, which measures 1·8 × 1·8 in antero-posterior and transverse dimensions. These dimensions, to judge from an entire bone in the British Museum, from Grays Thurrock (no. 23761), which measures 1·7 × 1·7, would give the Oreston metatarsal a length of 7·41,

TABLE I.—*Middle Metacarpal.*

Species.	Place of Deposit.	Locality.	Length.	Least circumference.	Proximal end. ap.d. × tr.d.	Distal end. ap.d. × tr.d.	Shaft at middle. ap.d. × tr.d.	Trochlea. tr.d.	Perimetral index.	Latitudinal index.
R. lepto-rhinus.	No. 905 R. C. S.	Oreston.	9·2	5·4	22×24	20×28	9×22	2·50	·586	·409
	No. 25761 B. M.	Grays Thurrock.	8·8	5·5	21×25	20×29	9×24	2·40	·625	·375
	B. M.	Grays Thurrock.	8·7	5·5	20×25	20×28	9×24	2·40	·626	·375
R. ticho-rhinus.	Oxford.	Wirksworth.	7·8	5·25	×25·6	×26	11×19	2·25	·673	·578
	B. M.	Kent's Hole.	6·8?	5·15	16×23	21×26	11×23	2·25	·757	·478
	B. M.	Amiens.	7·35	......	16×24	13×24	10×19	2·20	......	·526
		Stratford-on-Avon.	7·4	5·8	20×26	19×26	11×23	2·25	·783	·478
		Bengeworth.	7·0	4·9	20×25	17×23	9×20	2·00	·700	·450

TABLE II.—*Middle Metatarsal.*

Species.	Place of Deposit.	Locality.	Length.	Least circumference.	Proximal end. ap.d. × tr.d.	Distal end. ap.d. × tr.d.	Shaft at middle. ap.d. × tr.d.	Trochlea. tr.d.	Perimetral index.	Latitudinal index.
R. lepto-rhinus.	No. 23761 B. M.	Grays Thurrock.	7·75	5·0	—×24	19×29	9×21	2·3	·646	·428
	No. 19842, B. M.	„	8·0	5·2	—×25	19×28	9×21	2·2	·650	·428
R. ticho-rhinus.	B. M.	Kent's Hole.	6·6	5·0	18×22	—×22	10×20	2·0	·739	·500
R. hemitœchus.	Brady Coll.	Ilford.	6·7	4·2	16×19	16×21	9×18	1·8	·631	·500
	„	„	6·3	...	16×20	14×20	×17	1·85	......	......
	No. 20245. B. M.	„	6·8	4·4	18×20	16×22	9×18	1·9	·661	·500
	No. 20267. B. M.	Grays.	6·4	3·9	16×17	19×19?	8×16	1·7	·609	·500
	G. B.	Gibraltar.	6·6	4·2	15×17	15×21	8×18	1·85	·636	·432
R. etruscus.	B. M.	Val d'Arno.	6·9	3·9	15×19	18×20	9×16	1·7	·565	·563

NB.—In the 6th, 7th, and 8th columns, the figures represent tenth parts of an inch.

which very considerably exceeds that of the same bone in either *R. tichorhinus* or *R. hemitœchus*, whilst it is quite in proportion with that of the metacarpal above described.

I have carefully surveyed the other bones in the Oreston Collection, but think it unnecessary to say more concerning them than that they seem to me to be all in accordance, as regards proportions, with the metacarpal and metatarsal, hoping that what I have ventured to remark concerning those bones and the teeth will be enough to establish the proposition with which I started.

Discussion.

The Chairman remarked that at one time the Oreston *Rhinoceros* was referred to *R. tichorhinus*, but that Buckland, although mentioning the *Rhinoceros*, never gave it a specific name. The Chairman also said that the Oreston fissures were not caves, but mere fissures which had been filled in; an entire skeleton occurred at one spot, and the animal must have fallen in.

Mr. Boyd Dawkins had been struck by the non-tichorhine character of the Oreston specimens some years since. He confirmed Prof. Busk's determination, and remarked that five British species of *Rhinoceros* are known, namely:—1. *R. Schleiermacheri*, from the Red Crag of Suffolk (in the Miocene at Darmstadt); 2. *R. etruscus*, from the Forest Bed = *R. Merckii* (Von Meyer); 3. *R. megarhinus* (Christol)=*R. leptorhinus* (Cuv.); but the latter name includes also *R. etruscus* and *R. hemitœchus*; so that the adoption of De Christol's name gets rid of a difficulty; 4. *R. hemitœchus*; and, 5. *R. tichorhinus* =*R. antiquitatis* (Blum.).

Prof. Busk, in reply, stated that Oreston was a fissure-cavern, and noticed the successive openings in 1816, 1821, and 1826. He did not agree with Mr. Boyd Dawkins in preferring the name *megarhinus* to Cuvier's *leptorhinus*. He did not know of the occurrence of two species of *Rhinoceros* at Oreston.

---

2. *On* two Gneissoid Series *in* Nova Scotia *and* New Brunswick, *supposed to be the* Equivalents *of the* Huronian (Cambrian) *and* Laurentian. By Henry Youle Hind, Esq., M.A.

(Communicated by Professor Ramsay, F.R.S., F.G.S.)

[Plate XXX.]

Contents.

I. Introduction.

The descriptions contained in this paper, so far as they relate to Nova Scotia, are in the main the results of observations during the summers of 1868 and 1869, while making geological surveys for the Nova-Scotian Government, in the gold-districts of Waverley and Sherbrooke. The comparisons with New Brunswick are based on my official Report on the Geology of that Province*, published in 1865; and the references to Cape Breton, when not otherwise stated, are from MS. notes of explorations in that island during 1866.

The accompanying maps (Pl. XXX.) embrace part of Halifax, Hants, and Guysborough Counties in Nova Scotia, and in New Brunswick a broad belt extending from the Bay of Chaleurs to the boundary line between New Brunswick and Maine†.

Geological maps of Nova Scotia were published by Dr. Abraham Gesner in 1836‡, by Dr. Dawson in 1865§ and in 1868‖, and by Sir William E. Logan in 1865¶ and in 1869**.

Sir William Logan states, in the introduction to his 'Atlas of Maps and Sections,' that for the geology of Nova Scotia "a manuscript map by Dr. J. W. Dawson, compiled from his own researches and those of Messrs. R. Brown and H. Poole, has been the source of information." Hence, in making the necessary comparisons between the subject of this paper and the published descriptions and maps of Nova Scotia, I shall have to refer almost exclusively to Dr. Dawson's maps of 1868, accompanying the 2nd edition of his beautiful work on Acadian Geology.

In a Preliminary Report†† on the supposed Laurentian of Nova Scotia, I have quoted some passages from Dr. Dawson's work, especially the explanation to the geological map, in which the uncertainty of the boundaries of formations, and the doubtful age of some strata are adverted to. The recognition of very large gneissoid areas in Nova Scotia, supposed to represent two series not hitherto described as occurring in the Province, will enable some of the changes in part anticipated by Dr. Dawson to be foreshadowed with some degree of accuracy; and it is proper to repeat here Dr. Dawson's first paragraph of the 'Explanations to the Geological Map:'—"The map in this edition, though greatly improved, is still to be regarded

* Preliminary Report on the Geology of New Brunswick: Fredericton, 1865.

† In southern New Brunswick Professor Bailey and Mr. Matthew have discovered Laurentian and Huronian rocks. They are described in their 'Observations on the Geology of Southern New Brunswick' (Fredericton, 1865); also in an able paper by Mr. Matthew, published in the Society's Journal for November 1865, "On the Azoic and Palæozoic Rocks of Southern New Brunswick."

‡ Remarks on the Geology and Mineralogy of Nova Scotia, by Abraham Gesner: Halifax, Nova Scotia, 1836.

§ Acadian Geology, 1st edition.

‖ *Op. cit.* 2nd edition: Macmillan and Co., London, 1868.

¶ Atlas of Maps and Sections: Montreal, Dawson Brothers, 1865.

** Geological Map of Canada and the adjacent Regions, 1869: London, Edward Stanford.

†† Preliminary Report on a Gneissoid Series underlying the Gold-bearing Rocks of Nova Scotia, and supposed to be the Equivalent of the Laurentian System: Halifax, Nova Scotia, January 5, 1870.

as merely a rude approximation to the truth; and the colouring in many places, more especially in the interior, remote from the coast-lines, is little more than conjectural."

In various parts of 'Acadian Geology' reference is made to rocks which were thought by Dr. Dawson might be older than the Lower Silurian slates and quartzites (see particularly p. 620, 'Acadian Geology,' 2nd edit.). These will probably now be classed with the Huronian series; and the massive porphyritic granitoid gneiss on which they rest, with the Laurentian.

Dr. Sterry Hunt visited Nova Scotia in November 1867, "for the purpose of making some observations on the gold-bearing rocks of that Province, with the view of comparing them with those of other parts of the Dominion, and also of obtaining such information as might be useful in the event of a geological survey of Nova Scotia itself."

Dr. Hunt's stay in the Province was limited to four weeks in the months of November and December; and in the descriptions which he has given in his official Report to Sir W. E. Logan*, he quotes the following as the principal sources of information about the geology and mineralogy of Nova Scotia:—Dr. Dawson's 'Acadian Geology,' 1st edit.; Mr. Poole's Report, 1862; Mr. J. Campbell's Reports, 1862 and 1863; Professor B. Silliman's Reports on Tangier, Waverley, and Montagu Goldfields, 1864. Dr. Hunt's opinion of the age of the gold-bearing rocks is expressed in the following paragraph:—"In the present state of our knowledge it appears probable that they may represent a part of the Lower Silurian Series, which, like the Upper Silurian and Devonian of this part of the continent, may be supposed to consist chiefly of non-calcareous sediments."

The Map (Pl. XXX. fig. 6) of part of New Brunswick between the Bay of Chaleurs and the State of Maine, "showing the disposition of the Gneissoid Series, part of which may be supposed to be of Laurentian age," is reduced from the original manuscript map which accompanied my Report on the explorations in 1865, and is described with some detail in pages 42–50 of the Report. The lines of section show where I crossed the gneiss belts; but, the intervening country being a rocky and wholly unexplored wilderness, the continuity of the bands is purely conjectural.

A copy of this Map was sent to Sir W. E. Logan in 1865; and allusion is made, in the 'References to the Atlas of Maps and Sections of the Geological Survey of Canada,' to opinions expressed in my report that much of the granites of New Brunswick consist of altered sedimentary strata†.

* Page 7, Report of Dr. T. Sterry Hunt, F.R.S., on the Gold-region of Nova Scotia.

† Much of what in Nova Scotia, New Brunswick, and Maine is represented on the Map as intrusive rock (chiefly granitic), probably consists of palæozoic strata altered *in situ*, as already suggested by Dawson and Hind. See the latter's 'Report on New Brunswick,' 1865, p. 50; 'Atlas of Maps and Sections, Geological Survey of Canada,' 1865.

II. General Sketch of the Distribution of the Supposed Huronian and Laurentian Series in Nova Scotia.

In this general sketch of the old gneissic rocks of Nova Scotia they are grouped together. In succeeding paragraphs it is stated where Huronian or Cambrian gneiss and schist rest on the Old Laurentian gneiss as far as known. The country occupied by these gneisses is for the most part an uninhabited wilderness.

The object of this paper is to show that two gneissoid series, supposed to be the equivalents of the Huronian and Laurentian of Sir W. E. Logan, are exposed over very large areas in Nova Scotia, the Island of Cape Breton, and in New Brunswick.

The outcrop of the Laurentian and Huronian in Halifax and Hants Counties has been traced from a point seven miles west of Windsor, on the Basin of Mines (Bay of Fundy), to the Atlantic coast at Cape Sambro, a distance of forty-eight miles in an air-line, and sixty-four miles on the margin of the outcrop. This is the north-easterly boundary of an immense area of the same rock-series which, from information hereafter noticed, I believe continues with variable breadth to the Tusket Islands, near Yarmouth, a distance of about 135 miles in an air-line.

The area above described forms the western development of the Laurentian and Huronian gneisses and schists in Nova Scotia. It is separated from the eastern development by a narrow profound valley, occupied by Silurian strata, whose least breadth is eight miles. The outcrop of the south-western boundary of the eastern development is not continuous, but, as shown on the map, embraces two areas near Grand and Parker Lakes, and an area of unknown but very considerable and variable width, stretching (with some narrow interruption of Silurian strata which have escaped denudation) probably all the way to the Strait of Canso and Chedabucto Bay, a distance of 120 miles in an air-line; so that, generally speaking, a Laurentian axis, capped here and there by strata of Huronian age, occupies Nova Scotia, certainly in one place at least forty-eight miles in breadth.

The existence in Nova Scotia of all formations, from the Trias to the Laurentian, with the exception of the Permian*, may now be regarded as very probable. Whether the rocks noticed in the footnote are of Permian or Triassic age, I am not able to say; but, judging from the descriptions given of the relations of the Triassic to the Carboniferous by Dr. Dawson, I have hitherto considered

* In Cape Breton, at Jumping Brook, seven miles north-east of Chetican Island, on the Gulf coast, and at Trout Brook, five miles north-east above Chetican, mottled sandstones and conglomerates rest unconformably on white and mottled sandstones and bituminous shales, supposed to be of Lower Carboniferous age. These latter rest unconformably, the first on red metamorphic rocks; the second are seen in close proximity to red, green, and black corrugated schists, supposed to be of Lower Silurian age. In Dr. Dawson's tabular view of the geological formations of the Acadian Provinces (Acadian Geology, p. 19) the Permian is stated to be "not represented, unless by the lower part of the sandstones of Prince Edward Island." May not the unconformable patches in Cape Breton be a continuation of these Prince-Edward-Island deposits?

small unconformable patches in Cape Breton of Triassic age, and regarded them as the continuation of the Prince-Edward-Island series, resting on Lower Carboniferous rocks.

In the accompanying map (fig. 1) the regular sequence is shown between the Upper Silurian and the Laurentian; and the entire series from the Lower Carboniferous, with the exception of the Devonian, is passed over in a journey by rail from Windsor to Halifax, in a distance of fourteen miles. The Devonian occurs at Nictau, and rests there on Upper Silurian slates*, which probably sweep round the Falmouth mountains, and connect with the Upper Silurian shown on the Map.

III. Sequence of Formations†.

The Upper Silurian.—On the St. Croix river, eight miles from Windsor, the Lower Carboniferous grits are seen to rest on supposed Upper Silurian argillites. The grits dip N. 60° W. 5°; the argillites S. 70° E. 50°. The argillites are generally very fine-grained, green internally, but weathering red; they are interstratified with thin beds of quartzites, and have a breadth, near the railway, of 170 chains, their dip being tolerably uniform, and no repetitions visible; their thickness may approach 9000 feet.

The argillites resemble in every particular argillites seen on the Tobique, in New Brunswick (fig. 6), and there associated with thin calcareous beds holding *Favosites gothlandica.* These are described in my Report on New Brunswick‡.

Towards the upper portion of the series the argillites are conformably succeeded by bluish-black slates, holding cubical crystals of iron pyrites, and resembling roofing-slates. A similar change occurs on the Tobique, in New Brunswick. These bluish-black slates are exposed to a great extent on the Ardoise hill-range, Nova Scotia.

The Lower Silurian.—A good exposure of the supposed blue-black Upper Silurian slates is visible at the thirteenth telegraph-post south of Ellerhouse station, on the Halifax and Windsor Railway, dipping S. 20° E.; and at the thirty-eighth telegraph-post brilliant micaceous schists, with black corrugated slates, dip N. 40° E., the intermediate space being covered with boulder-drift§. The brilliant micaceous schists, as well as corrugated slates, are much contorted, and overlie conformably the gold-bearing quartzite series.

The micaceous schists and the corrugated black slates cannot be distinguished from similar schists and slates described in my New-

* Dawson's 'Acadian Geology,' 2nd edition, p. 498.

† In the 'Journal of the Geological Society' for 1862 (No. 72) there is a paper "On the Geology of the Gold-fields of Nova Scotia," by Dr. Honeyman, with a sketch map of a part of Nova Scotia between Halifax and Windsor.

‡ Page 131.

§ In the absence of fossils the rocks in the preceding paragraphs are regarded as Upper Silurian, the difference between them and the strata next described being considerable; nevertheless, actual contact not having been seen, they may be a recurrence of the Lower Silurian beds on the other side of a great synclinal fold, and less altered than those in closer proximity to the gneiss.

Brunswick Report as occurring on the Nipisiquit, and near Dumbarton station, on the New Brunswick and Canada railroad (pp. 147 and 154), where they are associated with the red slates supposed to be the uppermost member of the Quebec group of Sir W. E. Logan. The black corrugated slates contain conformable auriferous beds of quartz; but no mining is at present carried on in these deposits. They are about 3000 feet in thickness, and are conformably underlain by the gold-bearing rocks.

The Gold-bearing Rocks.—The known gold-bearing rocks of Nova Scotia consist of quartzites, sandstones, and grits, interstratified with argillaceous slates, and thin conformable beds and intercalated beds of auriferous quartz. The portion has an ascertained thickness exceeding 9000 feet; and between the base and a vertical thickness of about 3000 feet from the summit, the thin beds of quartz yielding gold are found, and are worked in different districts in this Province, so that a mass of strata having a thickness of 6000 feet, or more than a mile, yields gold from quartz-beds of contemporaneous age with the quartzites and slates with which they are interstratified; and it is from these quartz-beds that the greater part of the gold of Nova Scotia is obtained*. The total thickness of the gold-bearing series, including the corrugated black slates and the brilliant micaceous schists, is about 12,000 feet.

IV. The Cambrian, or Huronian Series.

In some parts of Nova Scotia the known gold-bearing rocks rest unconformably on a gneissoid series, well exposed to view on the Halifax and Windsor Railway, between the Stillwater and Mount Uniacke Stations (Pl. XXX. fig. 1), and near the village of Sherbrooke, in Guysborough County (fig. 4). This series is composed of beds of gneiss, interstratified with micaceous schists, schist conglomerate, beds of true quartzite, and grits. The gneiss is sometimes porphyritic; and the upper beds are almost always conglomerate, holding pebbles and masses of schist, grits, and conglomerates, which are found in this series. Some of the gneissic strata are granatiferous, as are also the micaceous schists. Between Stillwater and Mount Uniacke Stations the general strike of the Lower Silurian is N. 80° E., dip N. 80°; the prevailing strike of the Huronian is S. 50° E., the railroad-track running for two or three miles on the strike of these rocks. Near to their junction with the Huronian, the Silurian strata are more altered than where remote from them, and hold numerous crystals of andalusite. This series has been very extensively denuded, and in some places Silurian, Huronian, and Laurentian are seen in close juxtaposition. The thickness at Sherbrooke is about 1300 feet.

When the preliminary Report already referred to was in the hands of the printer, I satisfied myself, by repeated observations, that a very decided unconformability existed between these supposed older strata and the gold-bearing series, also between the older

* *Vide* my Report on the Sherbrooke Gold-District for a description of the auriferous lodes, distinguishing between contemporaneous and intercalated lodes.

strata and the Laurentian; and I have succeeded in discovering in various places:—

1st. The unconformable contact of the Lower Silurian gold-bearing strata with the underlying gneissoid and schistose series.

2nd. The unconformable contact of this gneissoid and schistose series with the old porphyritic gneiss which I had before described as Laurentian.

3rd. The unconformable contact of the gold-bearing series with the old Laurentian gneiss, showing the absence of the intermediate gneissoid series, or the Huronian.

These several points of contact are visible at both extremities of a patch of Huronian strata about four miles broad, overlying the Laurentian on the Windsor and Halifax Railway, commencing one mile, or thereabouts, south-east of new Stillwater station, and terminating at Uniacke's second lake, and more than half a mile west of Mount Uniacke station.

V. The Laurentian Series.

The rocks last described are visible, as already stated, in unconformable contact with a coarse porphyritic granitoid gneiss near Stillwater station. The strike of the granitoid gneiss is N. 10° W., dip W., at an angle of about 48°. Five miles further south, and within a third of a mile of Mount Uniacke station, the Silurian quartzites rest on the Laurentian gneiss, the quartzites having a strike N. 75° W., and the old gneiss N. 20° W. Between Stillwater and Mount Uniacke the Huronian series rests on the old gneiss, and the Silurian on the Huronian; but north of Stillwater and south of Mount Uniacke the Silurian strata are in contact with Laurentian gneiss, and so continue until another patch of Huronian is reached, this last-named series appearing to cover comparatively small areas in the great Laurentian valley between Halifax and Windsor; but in the more western counties it is exposed, I have reason to believe, to a very considerable extent.

In the county of Guysborough (fig. 4) the gold-bearing rocks at Sherbrooke rest on the Huronian, which, again, is seen close at hand in contact with the old Laurentian gneiss. In the middle and eastern part of Nova Scotia the thickness of the Huronian does not appear to be very considerable; but no complete section has yet been crossed, except at Sherbrooke (fig. 5). Between Halifax and Windsor the Lower Silurian series occupies a great valley or synclinal fold in the old Laurentian gneiss. The average breadth of the valley is nine miles. Its general course is north-west (true); and the gold-districts of Mount Uniacke and Hammond's Plains are arranged on its western boundary—and those of Lawrencetown, Montagu, Waverley, and Renfrew on the eastern boundary of the valley, occupying crowns of anticlinals which have a general north-east-by-east direction (fig. 1).

In one part of the county of Guysborough the Laurentian, with a narrow band (as far as known) of Huronian, forms a nucleus, having

an area of about 120 square miles. Around this nucleus the gold-districts of Cochran's Hill, Sherbrooke, Wine Harbor, Isaac's Harbor, and Country Harbor are arranged, also on the crown of anticlinals, which have a general easterly and westerly direction.

The profound Silurian valley shown in the map (fig. 1), between Halifax and Windsor, divides the Atlantic portion of Nova Scotia proper into two distinct geological areas, in both of which the old porphyritic Laurentian gneiss forms the axis around which Huronian and Silurian series are arranged; but, with respect to the precise limits of these formations, little is known west or east of the area shown on the plan.

From Dr. Dawson's published maps and descriptions, Mr. Poole's manuscript map of the western part of the peninsula, and the numerous rock-specimens collected by that gentleman, and placed at my disposal by the Commissioner of Mines, coupled with valuable information derived from other sources, I infer that this coarse Laurentian gneiss extends in one unbroken sheet of strata, but of variable width, a distance of ninety miles west of Windsor, and occupies a large portion of the uninhabited wilderness in that part of the Province. Much of the gneiss, schist, and mica-slate seen by Mr. Poole, and described in his Report, and illustrated by his specimens, together with the gneiss, mica-schist, and chloritic beds alluded to by Dr. Dawson, and by that geologist long ago spoken of as probably older than the Lower Silurian, are doubtless the representatives in many instances of the Huronian in the district where they occur.

In the autumn of 1868, Dr. Honeyman, then engaged on the Geological Survey of Canada, discovered on the Gulf-coast of Nova Scotia, in the Arisaig district, and near the base of the Antigonish mountains, syenites, diorites, and crystalline limestone, with serpentine. Specimens were sent to Montreal for examination; and instructions were given by Dr. Hunt to the lapidary to prepare sections of the serpentinous rock for microscopical examination. By some mischance this was neglected, and the specimens remained unexamined, and indeed forgotten, until quite recently, as Dr. Hunt informs me, under date Feb. 3, 1870. When submitted to the microscopic test, forms resembling *Eozoon canadense* were distinctly seen. These may be of Laurentian age*.

In other parts of Nova Scotia the Laurentian is yet known only in the form of coarse porphyritic gneiss; but the area it occupies is a lake and forest wilderness, frequented only by the lumberman and hunter.

The descriptions given by Sir W. E. Logan of a similar rock in the Laurentian of Canada apply exactly to the characteristic strata in Nova Scotia. "The coarse-grained granitoid and porphyritic varieties, which often form mountain masses, sometimes have, at

* The existence of the *Eozoon* has recently been established in limestones and serpentines, now known to be of Laurentian age, by Dr. Sterry Hunt, in Massachusetts. An account of this discovery is given in the last number of the 'American Journal of Science,' Feb. 1870.

first sight, but little of the aspect of stratified rocks, and might be mistaken for intrusive granites"*.

Cape Breton.—In Cape Breton I saw, in 1866, the black corrugated slates forming the summit of the gold-bearing series of Nova Scotia, about five miles north of Chetican Island, on the Gulf-coast; and on the Mackenzie River, near Red Cape, I crossed part of a great gneissoid series †.

In various parts of Cape Breton I have seen similar gneisses, as for instance, near the mouth of North River, St. Ann's Bay, and on the peninsula opposite Baddeck.

Dr. Honeyman informs me that he considers the gold-bearing rocks of Middle River, in Cape Breton, to be of the same age as those of Nova Scotia. Hence it becomes more than probable that a very large portion of the area coloured by Dr. Dawson to represent Upper Silurian in the northern part of the island is occupied by rocks of Huronian and Laurentian age ‡.

Three Subordinate Laurentian Axes.—The sketch section of part of Canada, New Brunswick, and Nova Scotia (fig. 3), showing the outcrop of the gneissoid rocks, points to three subordinate undulations which have brought up the gneissic rocks between the Atlantic coast of Nova Scotia and the great Laurentian axis of the American continent on the north side of the St. Lawrence.

The first of these is the central belt of New Brunswick, which is parallel to the great axis north of the St. Lawrence. In the trough between the St. Lawrence and this belt the newest rock known is an outlier of Lower Carboniferous age.

The second axis trends slightly to the eastward, and the rocks are exposed from the coast of Maine to a considerable distance beyond the city of St. John, enclosing a wedge-shaped trough in which the New-Brunswick coalfield is situated.

The third axis is in Nova Scotia, and the newest rock in the intervening trough is the New Red Sandstone,

On the Atlantic coast of Nova Scotia, and on the south-east side of the Nova-Scotian axis the newest rocks consist of patches of the Lower Carboniferous, so that in each trough we find a recurrence of the same rock-series.

From the horizontal attitude of the Carboniferous series in Nova Scotia and New Brunswick, sometimes resting on the gneiss, sometimes on tilted Devonian or Silurian strata, it appears probable that these great undulations occurred at the close of the Devonian period.

The three great axes just enumerated represent the main undulations; but they are themselves thrown into minor corrugations,

* Geology of Canada, 1863, p. 587.

† See page 11 of a 'Preliminary Report on a Gneissoid Series underlying the Gold-bearing Rocks of Nova Scotia, and supposed to be the equivalent of the Laurentian System,' by the Author.

‡ In the counties of Addington, Hastings, and Peterboro', Ontario, there is a series of rocks provisionally placed by Sir W. E. Logan as Lower Laurentian, "at the base of which there appears to be an auriferous band." See page 5, Summary Report of Progress in Geological Investigations, May, 1869 (Geological Survey of Canada).

which in New Brunswick and Nova Scotia preserve a remarkable parallelism. These corrugations, in the descriptions of the structure of the Nova-Scotian gold-districts, are termed the east and west anticlinals*.

VI. Relation of the Gold-Districts to the Gneissic Areas.

The north and south anticlinals are low broad undulations which have ridged the country (Nova Scotia) in a nearly meridional course. At the intersection of the north and south with the east and west anticlinals, the gold-districts of Nova Scotia are situated; and it is here also that denudation has occasionally exposed the gneissic rocks in patches, like islands in a Silurian sea.

The map of the gneissic rocks in the county of Guysborough, Nova Scotia (fig. 4), is an illustration of this form of outcrop; and the map showing the Silurian valley between Halifax and Windsor (the Atlantic and the Bay of Fundy) exhibits the protecting influence of the north and south synclinals (fig. 1).

Where islands of gneiss occur in Nova Scotia, the gold-districts are symmetrically arranged around them—the outcrop of the lodes (which are beds of quartz) having a semielliptical form, the base of the ellipse resting on the gneiss.

Where they occur in a Silurian valley, between great exposures of gneiss, as represented on the map showing the structure from Halifax to Windsor (fig. 1), the exposed edges of the beds of quartz have also a semielliptical form; and if two districts are situated on opposite sides of the valley, the apices of the semiellipses point towards each other, their bases resting on the gneiss, as in the case of Waverley and Mount Uniacke.

Where denudation has not reached the gneiss, the outcrop of the bedded lodes may have any of the symmetrical forms which can be produced by the intersection of plane and curved surfaces.

From the uniform distribution of the auriferous beds of quartz in the Silurian rocks of Nova Scotia, we may expect to find accessible deposits at the intersection of the anticlinals all over the Province, where they are not concealed by superior formations; and since denudation has taken place to the greatest extent near gneissic areas, it may be anticipated that the correct mapping of these rocks will be of considerable economic advantage to the Province.

Recent operations in the gold-district of Waverley have afforded very satisfactory proofs of the contemporaneous bedded structure of many of the Nova-Scotian lodes, and also of the general structure assigned to the districts, and of their occurrence at the intersection of cross anticlinals as well shown in the case of the recovered Tudor and North Lodes at Waverley, and in the districts of Waverley and Sherbrooke generally, which are types of all the known gold-districts of Nova Scotia.

These proofs are thus referred to by the Chief Commissioner of

* See 'Reports on the Waverley and Sherbrooke Gold-Districts,' by the Author.

Mines in his Report for last year*:—"The most noticeable feature in this district is the tracing of the southern outcrop of the celebrated Tudor Lode, by a series of openings connecting two points 1100 feet distant, and thus proving the correctness of the views entertained by Professor Hind of the geological structure of this district, as described in his report and fully exemplified in the map accompanying that Report."

They are also noticed by the Inspector of Mines, who states:—"The trending of the strike of this lode towards the north and east has been followed from the shafts to within a few feet of the old workings on the Tudor Lode; and its identification with that lode has been established, and the construction assigned by Professor Hind to this part of Waverley district confirmed"†.

EXPLANATION OF PLATE XXX.

Fig. 1. Map of parts of Halifax and Hants counties, Nova Scotia, showing the outcrop of the Gneissoid series and the position of the Gold-districts. Scale 12 miles to 1 inch.

Fig. 2. General section from Lawrence Town to Windsor (line A–B in fig. 1).

Fig. 3. Sketch section from the Atlantic at Halifax to the St. Lawrence, showing four Laurentian axes.

Fig. 4. Map of part of Guysborough county, Nova Scotia, showing the outcrop of the Gneiss and the position of the Gold-districts. Scale 8 miles to 1 inch. (The names of the gold-districts are in capitals, with lines above and below them.)

Fig. 5. Section from Cochran's Hill to Burns Tilt (line A–B in fig. 4).

Fig. 6. Map of part of New Brunswick between Bay of Chaleurs and the State of Maine, showing the disposition of the Gneissoid series. Scale 26 miles to 1 inch.

DISCUSSION.

Principal DAWSON spoke in confirmation of the fact that the Palæozoic rocks are underlain by Laurentian gneiss &c. quite to the eastern coast of British North America, and stated that the same relation occurred in Newfoundland, and had been traced southwards into Massachusetts. He confirmed Mr. Hind's views generally, and stated that the Lower Silurian of Nova Scotia includes no great fossiliferous limestone like that of the interior of North America. The supposed *Eozoon* discovered by Dr. Honeyman was probably distinct from *E. canadense*, but was certainly a Foraminiferal organism allied to *Eozoon*; but as *Eozoon bohemicum* is of later date than *E. canadense*, the presence of *Eozoon* did not necessarily indicate Laurentian age.

Prof. RAMSAY suggested that other organisms besides *Eozoon* aided in building up these great calcareous masses. He inquired as to the mode of occurrence of gold, and suggested that the gold is obtained at the anticlinals merely because the exposure is better, and that it will be found to pervade the synclinals also.

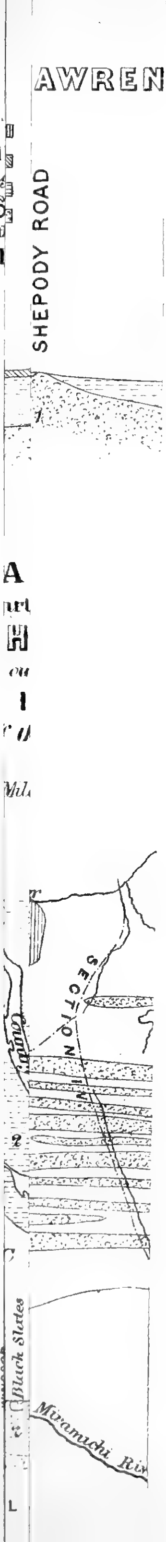
Mr. HENRY ROBINSON had visited the Waverley district, in com-

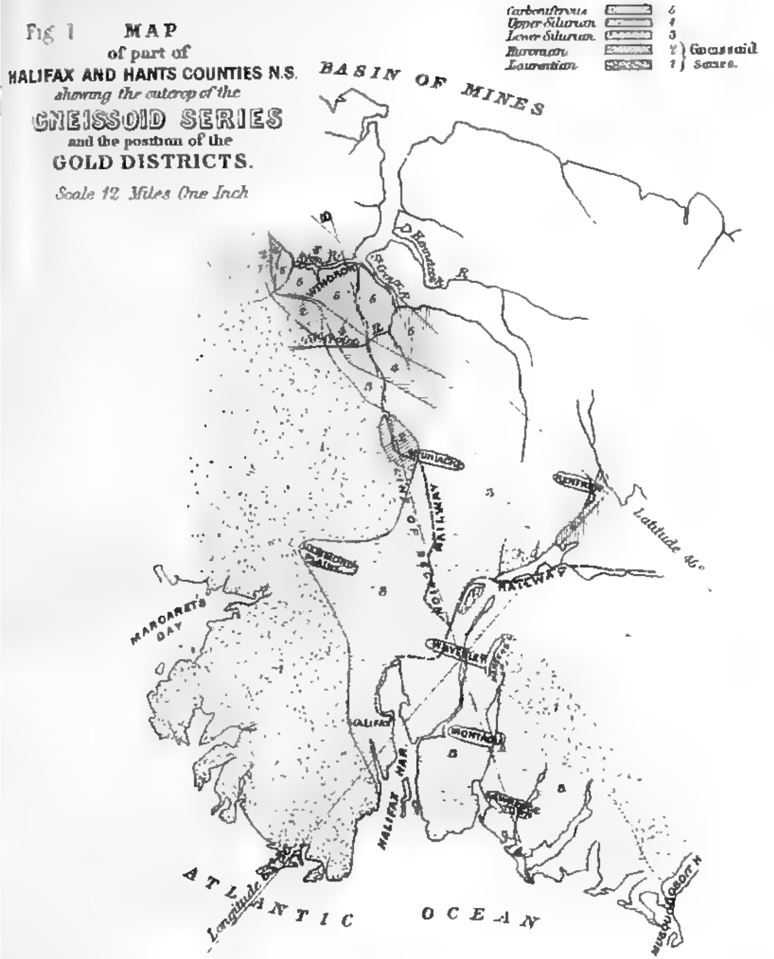
* Report of the Chief Commissioner of Mines for the Province of Nova Scotia for the year 1869, p. 9: Halifax, 1870.

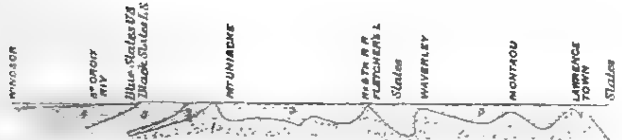
† *Ibid.* p. 38.

Fig. 1.

HALIFAX AN
showing
GNEIS
and t
GOLI
Scale,

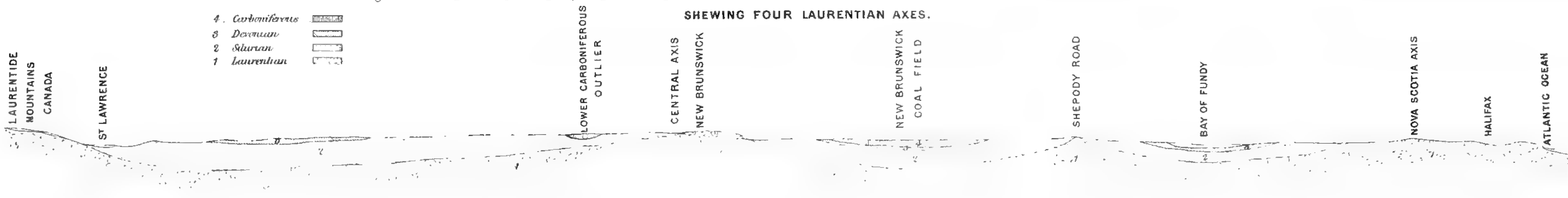


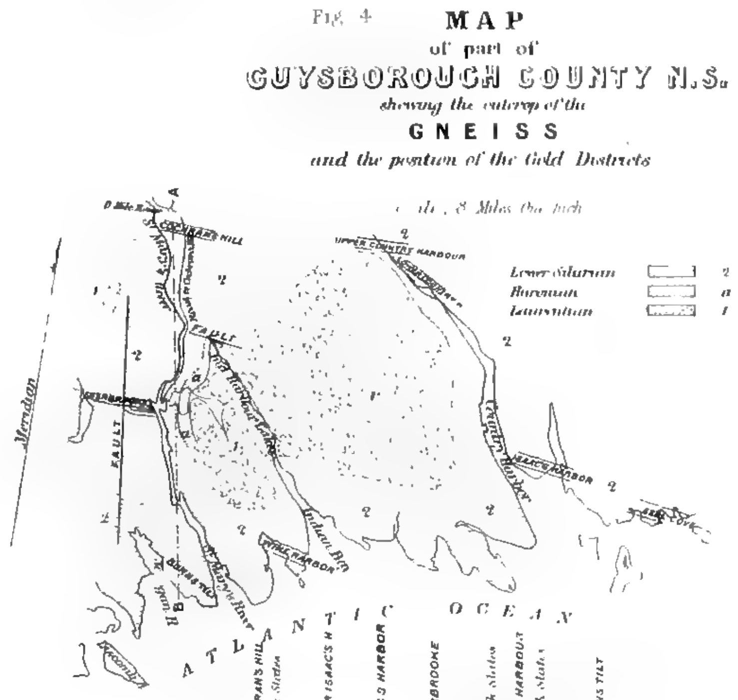




GENERAL SECTION FROM LAWRENCE TOWN TO WINDSOR (A B)

Fig. 3 SKETCH SECTION FROM THE ATLANTIC AT HALIFAX TO THE ST LAWRENCE, SHEWING FOUR LAURENTIAN AXES.





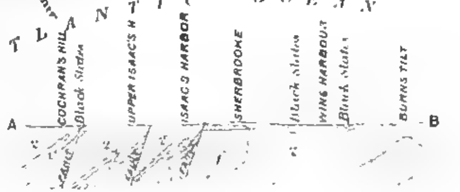


Fig. 5 SECTION FROM COCHRAN'S HILL TO BURNS TILT (A B)

GNEISSOID SERIES OF HALIFAX & NOVA SCOTIA

pany with Prof. Hind, in the winter of 1868, at which time the mining on the lodes referred to in the map before the Society was at a standstill, the lodes having been lost by reason of a fault. He thought it was very satisfactory to find that the theoretical position which Prof. Hind, from his explorations, assigned to the lodes had been completely verified. Mr. Robinson also stated that gold is being mined in the synclinals by sinking shafts and driving cross cuts.

Mr. Hind remarked that all the Lower Silurian in Nova Scotia was auriferous, and that the gold was derived from the underlying Laurentian rocks. He stated that Sir W. E. Logan had indicated an auriferous zone in the Laurentian of Canada. Gold was finely distributed in the slates of Nova Scotia, as in Victoria, in the neighbourhood of lodes, according to Mr. R. Brough Smyth.

May 11, 1870.

Sir William Bagge, Bart., M.P., of Stradsett Hall, Market Downham, Norfolk; Colonel James Leslie Tait, of Montgomery, Alabama, U.S., and Dr. C. C. Caruana, of the Malta University, were elected Fellows of the Society.

The following communications were read:—

1. Notes *on some specimens of* Lower Silurian Trilobites. By E. Billings, Esq., F.G.S., Palæontologist of the Geological Survey of Canada.

(Plates XXXI. and XXXII.)

1. Asaphus platycephalus, *with some of the legs preserved.*

This specimen was collected in the Trenton Limestone, at the city of Ottawa, about ten years ago. When discovered it was lying flat upon a thin slab of limestone, and well preserved, with the exception of the eyes, which seem to have been forced inwards by pressure from above. It was also divided into two pieces by a fissure which extended diagonally across, from the first segment of the thorax on the left side to the fifth segment on the right.

It remained in the Museum for several years without attracting particular attention, until one day, observing that the part in front of the fissure was somewhat loosely attached, I removed it, and was surprised at finding, on the underside, not only the hypostoma in place, but also what appeared to be some of the legs of the animal. As the part behind the fissure was more firmly attached to the stone, I had it cut across just behind the eighth segment by the lapidary of the Survey. The remainder of the thorax was then easily split off. The pygidium came off with difficulty and in two pieces. All the pieces were then fastened together; and we thus obtained two specimens, one of which shows the underside of the Trilobite, and the other its impression on the stone.

On the underside (Pl. XXXI. fig. 1) a broad shallow groove extends

from the space between the two lobes of the hypostoma, where we must suppose the mouth to be situated, backwards along the median line to the pygidium. This corresponds in position to the sternum of the ordinary crustacea. The legs are arranged in eight pairs, the bases of each pair being situated exactly under one of the eight segments of the thorax, and at the sides of the sternal groove.

The legs of the first pair are better-preserved than the others. They curve forwards and can be traced to a point nearly under the outer edge of the eye, or, rather, between the eye and the outside of the head. The other seven pairs follow at the average distance of two and a half lines from each other. The eight pairs thus occupy about twenty lines of the length of the ventral surface. This is exactly the length of the thorax, measured on the upperside. This trilobite has always eight segments in the thorax; and there is thus on the underside one pair of appendages to each segment. Although some of them are very imperfect, and the portions that remain are somewhat displaced, with a little study of the specimen it can be seen that they all curve forwards, and are thus, most probably, ambulatory rather than natatory legs.

There appear to be several joints in each of these appendages; but the exact number cannot be made out. On the left side, the first four legs show very clearly that there are at least two, one at five lines from the side of the groove, and another about three lines further out. The position of each of these is indicated by a small protuberance (Pl. XXXI. fig. 1, *n*). On the right side the preserved portions of the legs are longer, and thus indicate a greater number of articulations, although they cannot be distinctly seen. I think that each leg consisted of at least four or five articulations.

On the pygidium there are three small ovate tubercles, arranged in a line, that seem to be organic (fig. 1, *d*); and if they are so, they are, perhaps, the processes to which respiratory feet were attached.

The length of the specimen is four and a half inches, and the width two and a half inches. On a side view the height of the head just behind the eyes is nine lines, and at the middle of the thorax about seven lines. The depth of the internal cavity at the back part of the head is seven lines, and at the last segment of the thorax four lines. The plane in which the legs are situated is therefore not so low down as the extremities of the pleuræ. The visceral cavity is thus about one-third less than the whole bulk of the animal (Pl. XXXII. fig. 1).

The above is all that I desire to say at present concerning this remarkable specimen. The first and all-important point to be decided is, whether or not the forms exhibited on its underside are truly, what they appear to be, locomotive organs. If this question be decided in the affirmative, it will then remain for Carcinologists and others to homologize them with the limbs of existing crustacea. It is scarcely necessary to remark, in this place, that, in view of the great zoological questions that are at present being discussed, the correct determination of the affinities of the Trilobites is of extraordinary importance.

A short notice of the specimen was drawn up and read before the Natural-History Society of Montreal in 1864. Publication, however, was delayed, partly because I hoped to obtain additional evidence, but principally because I wished to have the specimen first exhibited to the Geological Society, and examined by as many of the Fellows as possible. Feeling somewhat apprehensive that it would be difficult to persuade geologists and palæontologists into the belief of the existence of trilobitic legs by figures and descriptions alone, I thought it better to wait until the paper and the specimens could be laid before the Society at the same time.

During the six years that have elapsed, a vast number of Trilobites have passed through my hands, but nearly all of them in a fragmentary condition. Among such, I am satisfied, we may seek in vain for any traces of locomotive organs. We can only expect to find them in perfect or nearly perfect specimens. These latter, considering the prodigious multitude of these animals that must have existed in the Silurian and Devonian seas, are not abundant fossils; at least they are not so in our Canadian rocks. For example, during the twenty years that I have collected fossils, I do not believe that I have seen fifty specimens of *A. platycephalus* with with the head, thorax, and pygidium all in connexion. We have had a number of those belonging to the provincial collection cut up and polished, without any success whatever. They were not the best ones, but they were as perfect as was the subject of this notice before it was split apart. There are others in the collection which may have the underside preserved; but we do not like to sacrifice them. Although no additional evidence of the existence of limbs was discovered, several points in the structure of other parts were ascertained, which will be described further on. As Sir W. E. Logan is about visiting London, and has kindly offered to take charge of this paper, and will also take the specimens with him, I shall delay publication no longer.

2. *Discovery of the Panderian Organ* in several American species of* Asaphus.

The evidence afforded by the specimen above described, and others of which I have made sections, proves that in the genus *Asaphus* the underside was not flat, but somewhat concave. In the head, on each side of the mouth, there was a cavity like that which occurs in the existing king crab—*Limulus Polyphemus*. The position of these cavities is at c c, in Pl. XXXI. fig. 1. They are partially filled up in the specimen; but I have ascertained their depth to be about five lines in another individual of the same size. The ends of the pleuræ projected downwards a short distance below the level of the sternum. The pygidium was also concave at the sides, with a portion along the middle, holding the intestine, convex. This structure can be seen, in part, by examining the slab from which the specimen

* Dr. Volborth calls the organs in question "*die Pander'schen Organe*," a term of which I heartily approve, as, if generally adopted, it will permanently associate Dr. Pander's name with his discovery.

above noticed was split. Portions of the lower margins of the head and tail, and the extremities of some of the pleuræ, remained sticking in the stone. It can also be proved by polished sections through the head and tail of any well-preserved specimen. Such sections usually show that a portion of the crust, called the "doublure" by Barrande, all round the margin is folded under and reflected upwards, ending in a free thin edge (Pl. XXXI. figs. 2, 3, 4). The pleuræ have also a doublure, which extends upwards, nearly halfway to the median lobe of the body. In consequence of this structure the extremities of the pleuræ are hollow, exactly like those of a lobster.

In *Limulus* a similar doublure occurs; and we can see there that it is continuous with the thin membranous crust which covers the underside of the body and bears the limbs. Between the sternum of *Limulus*, with its load of ponderous legs, and the doublure there is no connexion, all round, except this fragile membrane. In consequence of this structure it often comes away with all its appendages, leaving nothing of the animal except its huge carapace, pygidium, and telson. Specimens of this great crab in this condition are common in museums.

In the genus *Asaphus*, and, no doubt, in all other Trilobites, the doublure is, as in these imperfect specimens of *Limulus*, only the remains of the integument which covered the underside and supported the sternum. These two genera, however, differ widely in other respects.

The doublure of *A. platycephalus* was figured by Dr. Bigsby so long ago as 1823, in the Geological Transactions, 2nd series, vol. i. pl. xxvii. fig. 1 *c*, among the illustrations of his paper "On the Geography and Geology of Lake Huron." The figure shows a section through the doublure on the right side, just in front of a line drawn across the head through the centres of the eyes. In the description of the figure the true character of the part in question is recognized, by the remark that "*the shelly crust of the under side joins the upper at the sides.*" It is also shown in fig. 1 *b*, on the same plate, which represents the underside of the same specimen, with the hypostoma in place*. In that paper this now famous Trilobite

* This is the second hypostoma ever figured. Barrande, in his great work on the Trilobites of Bohemia, commences the history of the organ in question, thus:—

"A. *Données Historiques.*

"1821. Le plus ancien hypostome connu, est figuré et décrit par Wahlenberg, sous le nom de *Entomostracites bucephalus* (Nov. Act. Soc. Sci. Upsal. viii. 37, pl. i. fig. 6).

"1822. Ch. Stokes découvre sous la tête d'*Asaphus platycephalus* (*Isotelus gigas*, De K.) une pièce crustacée, placée à l'entrée de l'estomac; et il la décrit dans les Transact. Géol. (nouv. sér. i. 208, pl. 27).

"La même année, le savant Américain De Kay décrit et représente le même appareil que nous retrouvons figuré par Buckland dans les *Bridgew. Treatises*, en 1837." (Barrande, Système Silurien &c. vol. i. p. 154.)

There is a difficulty about the nomenclature of this Trilobite, owing, in part, to some uncertainty as to the true dates of publication. In the later reports of our survey we have adopted the name given to it by Stokes, while most American authors call it either *Asaphas gigas* or *Isotelus gigas*. Dr. Bigsby's paper was

was first made known to science. It was named by Mr. Stokes. Very numerous figures of the doublure of different species of Trilobites may be seen in the large works of Barrande, Salter, and others; but it is described by some as a portion of the crust, folded under to give greater strength to the margins of the head and tail. This, however, is not the whole of its interpretation. It is (as above stated) a part of the underside, which, on account of its greater thickness and hardness, is usually preserved, while the more membranous and fragile portions have disappeared.

About twelve years ago, Dr. Pander discovered some small scars and tubercles on the inner surface of the doublure of the Russian Trilobite *A. expansus*; and they were afterwards described and figured by Dr. A. Volborth in several papers*. He supposes them to indicate the points of attachment of soft swimming-feet. Eichwald has also described and figured the same organs in *A. Schlotheimii*, but maintains that they are the sockets of the first segments of hard, horny, articulated, ambulatory legs†. These two distinguished naturalists have discussed the points in difference between them at length, and with their well-known ability, in the works cited below. I have discovered the same organs in three of our species—*A. platycephalus*, *A. canadensis*, and *A. megistos*. They are small rounded or ovate scars, with an elevated protuberance on one side. They are situated on the doublure, close to the anterior margins of the pleuræ. The protuberance leaves a small but distinctly marked pit in the cast of the interior, as is shown in Pl. XXXI. fig. 5. That organs of some kind were here attached, I think there can be little doubt. But what was their function? If they were legs, then *Asaphus* must have had four parallel rows of limbs beneath the thorax. If the two inner rows were ambulatory, as I suppose those of our Trilobite to have been, then the two outer rows may have been natatory, as Dr. Volborth maintains. Eichwald figures several slender articulated organs, which he supposes to be the legs of Trilobites; and indeed they resemble, not remotely, those of our specimen. For convenience of reference, I have copied his figures (Plate XXXI. fig. 6). If they are truly the same organs, he would still be, to some extent, wrong; for he thinks they were attached to the doublure.

---

read February 21st, March 7th, and 21st, 1823. It is usually cited under the date of 1822. In his article on the Minerals and Fossils of Canada, published in Silliman's Journal in 1824, vol. viii. p. 84, he alludes to it thus:—"I beg to refer to three figures of large unknown trilobites, published last year in the Geological Transactions of London." I infer from this that the portion of the Transactions containing his paper was issued in 1823. De Kay's paper, in which the species was first called *Isotelus gigas*, was read before the New York Lyceum of Natural History, October 27th, 1823. It is generally quoted with the date 1824.

* (1) Deutsche Petersb. Akad. Zeitung, 1857, No. 255; (2) Verhandl. der kaiserl. miner. Gesellsch. Jahrg. 1857–58, p. 168; (3) Mém. Acad. Imp. St. Pétersbourg, tome vi. No. 2, 1863; (4) Bull. Soc. Imp. Nat. Moscou, No. 1, 1866. I have only seen the last two of these.

† Lethæa Rossica, vol. i. pt. 2. p. 1364, pl. 52. fig. 24.

3. *Are* Protichnites *and* Climactichnites *the tracks of Trilobites?*

In his description of *Protichnites,* Prof. Owen says:—"The *Limulus,* which has the small anterior pair of limbs (near the middle line) and the next four lateral pairs of limbs bifurcate at the free extremity, the last pair of lateral limbs with four lamelliform appendages, and a long slender hard tail, comes the nearest to my idea of the kind of animal which has left the impressions on the Potsdam sandstone"*. In 1862, Dr. J. W. Dawson tested this opinion by actual experiment, on a sandy beach near the mouth of the Scarborough river, on the coast of Maine. Having caught a *Limulus* he kept it alive for several days, and "tried its mode of locomotion under various conditions on the sandy shore, and preserved sketches of the markings"†. His figures and descriptions prove clearly that the tracks on the sandstone could have been made by an animal having a structure like that of *Limulus.* The grooves along the side of the track were made by the edges of the broad cephalothorax, the small pit-like impressions by the extremities of the large limbs, the transverse grooves by the lamelliform feet, and the median groove by the telson. If it be granted that *Asaphus,* in addition to its thoracic legs, possessed a set of lamellar swimming-appendages under the pygidium, then the structure of the under-surface would be sufficiently like that of *Limulus* to enable it to produce the same markings. The median groove might be made by a Trilobite with a caudal spine like that of *Megalaspis heros* (Angelin). This species is a true *Asaphus.* The large Trilobite of the Potsdam sandstone, *Dikelocephalus,* differs little in general structure from *Asaphus,* while the pygidium of several of the species evinces a tendency to become spinous around the margin. The genus *Aglaspis* (Hall) appears to me to be a Trilobite of the same group; and, moreover, the specimens figured seem to be the tail and not the head. What are supposed to be the eyes are the bases of two spines, like the one that occurs on the pygidium of *Bathyurus spiniger* (*Acidaspis spiniger*, Hall).

Dr. Dawson, after comparing all the facts, says:—"On the whole we may safely conclude that, if any of the larger primordial Trilobites were provided with walking- and swimming-feet of the type of those of *Limulus,* but differing in details of structure, they may have produced both the *Protichnites* and the *Climactichnites.*" Prof. J. D. Dana, also speaking of the latter, says:—"It has been regarded as the track of a very large Gasteropod; but it is quite as probable that it was made by the clusters of foliaceous appendages of one of the great Trilobites—these appendages being its locomotive organs"‡. The following, therefore is the present state of the question:—

1. The tracks could have been made either by a *Limulus* or by a Trilobite.

* Quart. Journ. Geol. Soc. vol. viii. p. 224.
† Canadian Naturalist and Geologist, vol. vii. p. 276.
‡ Manual of Geology, p. 185.

2. No fossils of the order (*Xiphosura*) to which *Limulus* belongs have been found so low down as the Potsdam sandstone.

3. Large Trilobites occur there in abundance.

The weight of the evidence, therefore, favours the opinion that the tracks in question are those of Trilobites. It is important to bear in mind that *Protichnites* and *Climactichnites* occur together on the same slabs of sandstone. Dr. Dawson's observations clearly prove that both might have been made by an animal of the same species under different circumstances, accordingly as its walking- or its swimming-feet were made use of. Judging from the width of the tracks, I believe that several of those of both kinds on one of the slabs, now in the Museum of the Survey, were made by the same individual.

4. *On a rolled-up specimen of* Calymene senaria *filled with small ovate bodies.*

It is above stated that while seeking for additional evidence relating to the limbs of Trilobites, a number of specimens were cut up and polished. One of these was an exceedingly perfect, rolled-up *Calymene senaria*, from the Hudson-River group at Cincinnati, in Ohio.

This animal (Pl. XXXII. fig. 3) appears to have shut itself up so completely that the fine mud in which it was buried could only gain access through the small fissure at *a*, where the points of the head and tail come together. There is here a small space, within the letters, *c*, *d*, *e*, *f*, which is of a light yellowish brown. I think that neither the mud, nor even the muddy water, penetrated further. There is no trace of comminuted fossils in this space, as there is in most specimens that I have cut up. The whole of the remainder of the cavity is filled with a greenish-grey spar, with a patch in the back part of the head at *b* of a different colour. This spar holds a vast number of small ovate bodies (fig. 4), of which the greater diameter is about an eightieth of an inch, and the lesser a hundredth. They are of a lighter colour and more opaque than the matrix. When examined with a good glass, and under favourable light, they seem to float, as it were, in the spar. The hypostoma *c d*, is in place, and is here cut through. From the end of the tail, at *e*, a thin rough line runs inwards, nearly to the large spot at *f*, and is obscurely indicated thence to the end of the hypostoma at *c*. The spot *f* appears to be organic. It is of an ovate form, and has four or five obscure ribs across it at right angles to its greater diameter. There are other dark spots scattered irregularly throughout the matrix, that possibly may represent organic structures.

It is possible that the line *e f c* may represent the edge of the ventral integument cut through; for in a rolled-up trilobite this must be exactly its position. The small ovate bodies I believe to be the eggs.

EXPLANATION OF PLATES XXXI. & XXXII.

Plate XXXI.

Fig. 1. *Asaphus platycephalus*, Stokes.—Underside, showing the legs: *a b*, suture through the doublure; c, c, cavities on each side of the hypostoma; *d, d*, tubercles on the pygidium; *f f*, cephalic doublure; *l, l*, the two lobes of the hypostoma; *m*, position of the mouth; *n, n, n, n*, joints in the legs.

Fig. 2. Transverse ideal section through the thorax: *a, b*, the doublure of the pleuræ; *p*, position of the Panderian organ. The dotted line from *b* to *b* indicates the contour of the ventral surface.

Fig. 3. Ideal section through the head, cutting off the points of the hypostoma, *l, l*, in a plane passing through the eyes: 1, 2, position of the 1st and 2nd pairs of legs.

Fig. 4. Section through the tail of a small specimen, showing the doublure, *f f*.

Fig. 5. Three pleuræ restored, showing the position of the Panderian organ at *p*; *a, b*, portion of the pleuræ removed.

Fig. 6. Supposed leg of Trilobite, figured by Eichwald: *a*, natural size; *b*, enlarged.

Plate XXXII.

Fig. 1. *Asaphus platycephalus*.—Side view of the specimen which shows the legs, somewhat restored. The dotted line, *a b*, represents the position of the plane of the ventral surface nearly.

Fig. 2. Dorsal view of the same; the dotted lines indicate the position of the hypostoma and legs.

Fig. 3. *Calymene senaria*.—Section through the axis of the thorax: *a*, junction of head and tail; *b*, back of the head; *c d*, hypostoma; *e*, end of the tail; *f*, a body showing structure.

Fig. 4. A group of the small bodies in fig. 3, enlarged 8 diameters.

Fig. 5. The organic body seen at *f* in fig. 4, enlarged 3 diameters.

Discussion.

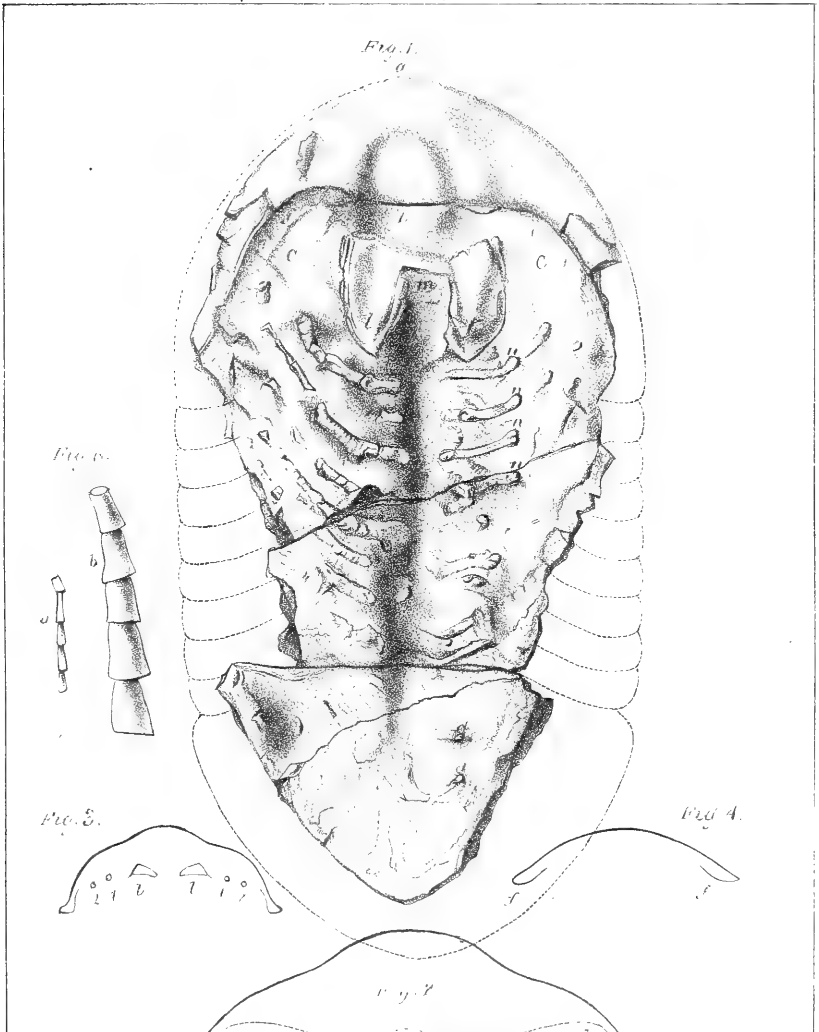
Mr. Woodward had carefully examined Mr. Billings's specimen, and agreed with him in considering that there was undoubted evidence of the presence of walking-appendages under the thorax. The presence of such limbs might *à priori* have been expected; and the nature of the test suggested that the Trilobites were walking rather than swimming forms of Isopods. The branchiæ had probably been under the telson; and this would account for its large development. It was not more surprising to find highly organized Trilobites than it was to find such highly organized crustaceans as *Pterygotus*, *Eurypterus* and *Slimonia* in the same beds.

Prof. Rupert Jones, Principal Dawson, and Sir Wm. Logan made some remarks, more especially on Protichnites and Climactichnites—the latter having been explained as galleries of Trilobites, by Prof. Jones, when first exhibited in England.

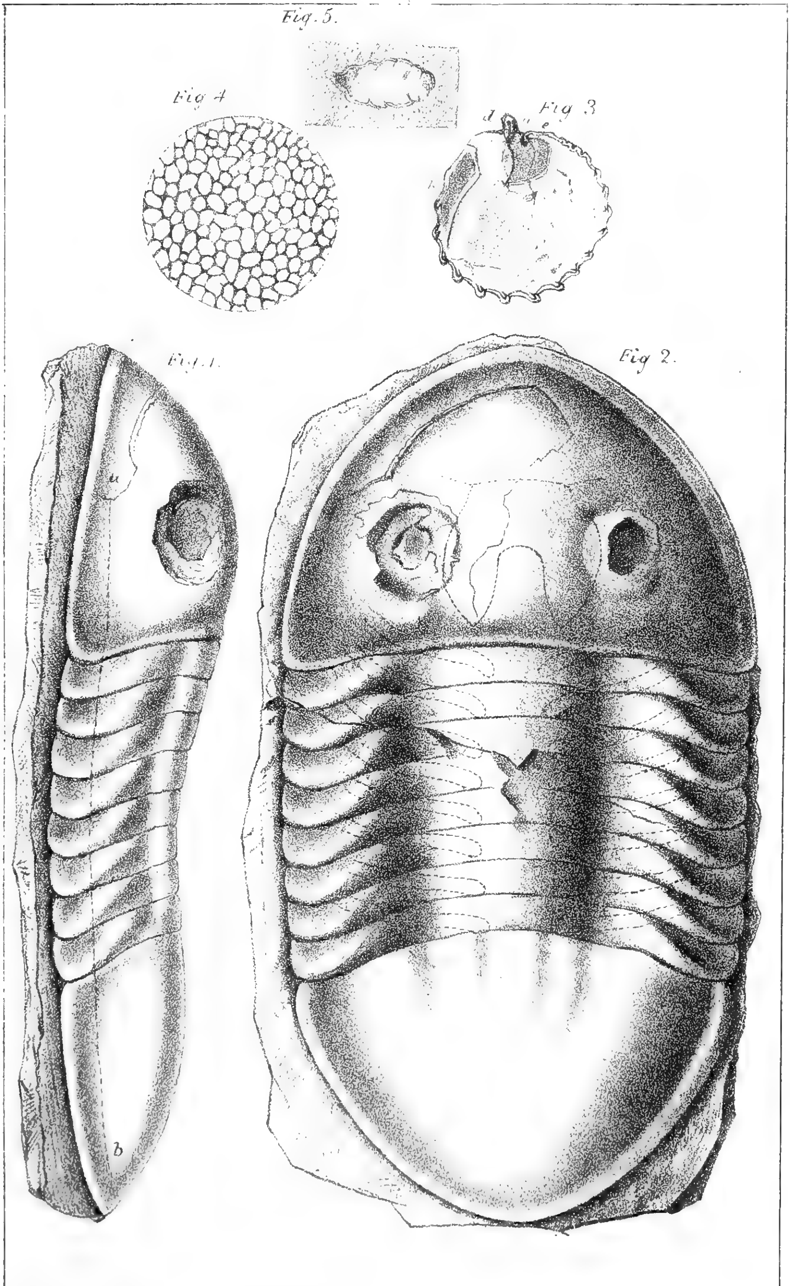
---

2. Note *on the* Palpus *and other* Appendages *of* Asaphus, *from the* Trenton Limestone, *in the British Museum*. By Henry Woodward, Esq., F.G.S., F.Z.S.

Having been requested by Sir William Logan to examine the Trilobite sent over by Mr. Billings from Montreal, I was led to compare it with certain specimens in the British-Museum collection, presented by Dr. J. J. Bigsby, F.R.S., some years since.



Horace S. Smith & A. T. Ho... del.   M & N Hanhart imp

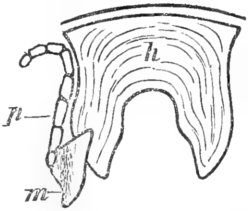


Horace S. Smith & A. T. Hollick del^t.

M. & N. Hanhart imp.

ASAPHUS AND CALYMENE.

Fig. 1.—*Buccal organs of* Asaphus platycephalus.



h, hypostoma; *p*, palpus; *m*, maxilla?

I was at once attracted by a specimen of *Asaphus*, from the Black Trenton Limestone (Lower Silurian), which has been much eroded on its upper surface, leaving the hypostoma, and what appear to be the appendages belonging to the first, second, and third somites, exposed to view, united along the median line by a longitudinal ridge. The pseudo-appendages, however, have no evidence of any articulations. But what appears to me to be of the highest importance, as a piece of additional information afforded by the Museum specimen, is the discovery of what I believe to be the *jointed palpus* of one of the maxillæ (Fig. 1), which has left its impression upon the side of the hypostoma—just, in fact, in that position which it must have occupied in life, judging by other Crustaceans which are furnished with an hypostoma, as *Apus, Serolis,* &c.

The palpus is 9 lines in length; the basal joint measures 3 lines, and is 2 lines broad, and somewhat triangular in form.

There appear to be about seven articulations in the palpus itself, above the basal joint, marked by swellings upon its tubular stem, which is 1 line in diameter.

There can be no reason to doubt that the Trilobita possessed antennules, antennæ, mandibles, maxillæ, and maxillipeds, as we find the same organs preserved in Crustacea of equal antiquity (*e.g. Slimonia acuminata* and *Eurypterus remipes*, both Upper Silurian forms).

With regard to the "Panderian organs" mentioned by Mr. Billings, I venture to suggest that the small circular impressions, seen upon the pleuræ of many Trilobites are only the *fulcral points* upon which the *pleuræ* move, and correspond to the ball-and-socket joints which mark the limbs and segments of all the higher Crustacea.

We know of no Crustaceans having *two pairs* of appendages to each segment; but it is characteristic of Crustacea to have their appendages bifid, giving rise to an endopodite and an exopodite; but these are always given off from a common base.

Having regard to the characters presented by the Trilobita as a group, we should be inclined to place them near to, if not actually in, the Isopoda Normalia.

In all this group, the branchiæ are abdominal, being placed under the broad and well-developed pygidium, which is not equivalent to the telson of the higher Crustacea, but is composed of several segments soldered together, in fact, representing the true abdomen. It is here, then, we should expect to place the branchiæ in the Trilobites, and not upon the epimera of the body-segments.

If any objection should be urged against the organs observed in the specimen in the British Museum being really legs, I would suggest that they may be considered good evidence of the presence of

those organs, and that they probably represent the apodemata, or infoldings, of the hard external crust to which those organs, or the muscles by which they were moved, were attached.

The prominence of the hypostome in the Trilobita reminds one even more strongly of the genus *Apus* than of the Isopods; and it is quite reasonable to expect, in the Trilobita, a more generalized type of structure than that which marks the modern representatives of the class.

The question will naturally be asked why so many specimens of Trilobites should be found, yet no traces of limbs. It seems reasonable to infer that a large number of these fossil remains are only *exuviæ*, the Crustacea frequently casting their shells. The detachment of the limbs is also a common occurrence in all the fossil Articulata, especially where, as in the Crustacea, the proximal joint is extremely constricted, and, in consequence, easily disarticulated.

Nor need we assume that all the genera of this very extensive family had horny or chitinous limbs, seeing that in the modern Isopoda a great diversity exists in these organs.

With regard to the section of *Calymene senaria* exhibited, it seems difficult to accept the suggestion that these are the eggs of the same Trilobite, seeing that they fill the entire cavity of the test, as shown in the section.

The publication of Mr. Billings's discovery appears to me to be of the highest importance to palæontologists; and he is entitled to our best thanks; for his observations are sure to excite further researches upon the Trilobita, and thus will be the means of greatly increasing our knowledge of this interesting group.

---

3. *On the* Structure *and* Affinities *of* Sigillaria, Calamites, *and* Calamodendron. By J. W. Dawson, LL.D., F.R.S., F.G.S., Principal and Vice-Chancellor of M'Gill University, Montreal.

(The publication of this paper is deferred.)

[Abstract.]

The object of this paper was to illustrate the structure and affinities of the genera above named, more especially with reference to the author's previous papers on the "Structures in Coal" and the "Conditions of Accumulation of Coal," and to furnish new facts and conclusions as to the affinities of these plants.

With reference to *Sigillaria*, a remarkably perfect specimen of the axis of a plant of this genus, from the Coal-field of Nova Scotia, was described as having a transversely laminated pith of the *Sternbergia* type, a cylinder of woody tissue, scalariform internally and reticulated or discigerous externally, the tissues much resembling those of Cycads. Medullary rays were apparent in this cylinder; and it was traversed by obliquely radiating bundles of scalariform vessels or fibres proceeding to the leaves. Other specimens were adduced to show that the species having this kind of axis had a thick outer

bark of elongated or prosenchymatous cells. The author stated that Prof. Williamson had enabled him to examine stems found in the Lancashire Coal-field, of the type of Binney's *Sigillaria vascularis,* which differed in some important points of structure from his specimens; and that another specimen, externally marked like *Sigillaria*, had been shown by Mr. Carruthers to be more akin to *Lepidodendron* in structure. These specimens, as well as the *Sigillaria elegans* illustrated by Brongniart, probably represented other types of Sigillarioid trees; and it is not improbable that the genus *Sigillaria,* as usually understood, really includes several distinct generic forms. The author had recognized six generic forms in a previous paper and in his 'Acadian Geology;' but the type described in the present paper was that which appeared to predominate in the fossil Sigillarian forests of Nova Scotia, and also in the mineral charcoal of the coal-beds. This was illustrated by descriptions of structures occurring in erect and prostrate *Sigillariæ,* on the surface of *Sternbergia*-casts, and in the coal itself.

The erect Calamites of the coal formation of Nova Scotia illustrate in a remarkable manner the exterior surface of the stems of these plants, their foliage, their rhizomata, their roots, and their habit of growth. Their affinities were evidently with Equisetaceæ as Brongniart and others had maintained, and as Carruthers and Schimper had recently illustrated. The internal structure of these plants, as shown by some specimens collected by Mr. Butterworth, of Manchester, and soon to be published by Prof. Williamson, showed that the stems were more advanced in structure than those of modern *Equiseta,* and enabled the author to explain the various appearances presented by these plants, when the external surface is preserved, wholly or in part, and when a cast of the internal cavity alone remains. It was further shown that the leaves of the ordinary Calamites are linear, angular, and transversely wrinkled, and different from those of *Asterophyllites* properly so called, though some species, as *A. comosus*, Lindley, are leaves of Calamites.

The *Calamodendra*, as described by Cotta, Binney, and others, and further illustrated by specimens from Nova Scotia, and by several interesting and undescribed forms in the collection of Prof. Williamson, are similar in general plan of structure to the Calamites, but much more woody plants; and, if allied to Equisetaceæ, are greatly more advanced in the structure of the stem than the modern representatives of that order. Specimens in the collection of Prof. Williamson show forms intermediate between *Calamites* and *Calamodendron*, so that possibly both may be included in one family; but much further information on this subject is required. The tissues of the higher *Calamodendra* are similar to those of Gymnospermous plants. The wood or vascular matter of the thin-walled Calamites consists of multiporous cells or vessels, in such species as have been examined.

In conclusion, a Table was exhibited showing the affinities of *Sigillariæ,* on the one hand (through *Clathraria* and *Syringodendron*) with Lycopodiaceæ, and on the other hand (through *Calamodendron*)

with Equisetaceæ; while in another direction they presented links of connexion with Cycads and Conifers.

DISCUSSION.

Mr. CARRUTHERS expressed his thanks for the amount of information given by Dr. Dawson, but was inclined to take a somewhat different view on some of the points mentioned. Some time ago he had, in a paper read to the Society, deduced from the internal structure of *Stigmaria*, the root of *Sigillaria*, that the latter was a true cryptogamous plant. He had since met with confirmatory evidence in a specimen of a fluted and ribbed *Sigillaria*, showing the internal structure of *Stigmaria*. Mr. Baily, in Devonian strata in Ireland, had found the root, stem, branches, leaves, and fruit of a plant which could, with certainty, be correlated. The root was a *Stigmaria*, the stem a fluted *Sigillaria*, the branches and leaves like those of *Lepidodendron*, and the fruit that of a cryptogam allied to *Lepidodendron*. With regard to the American specimens cited by the author, he would not speak with certainty; but he might suggest a different interpretation. The axis was probably foreign to the *Sigillaria* in which it was found, and was a true coniferous stem composed of pith, medullary sheath, and wood with medullary rays, and vascular bundles passing to the leaves. Plants growing in the interior of decayed Sigillarian stems had been mistaken for organic piths, though they belonged to two or three genera. Dr. Dawson's estimate of *Calamites* and allied genera essentially agreed with those which he held.

Dr. DAWSON thought that the views of Mr. Carruthers and his own might possibly be reconciled, and was not prepared to admit that the plant discovered by Mr. Baily was a true *Sigillaria*. It belonged, moreover, to the Devonian period, and not to the Carboniferous. He quite agreed with Mr. Carruthers in regarding the stems as closely allied with gymnosperms. He insisted on the layer at the base of the interior of the trunks of the erect *Sigillariæ* affording evidence of the interior structure of the plant, inasmuch as it consisted of the compressed and decayed inner tissues of the tree. It was curious that similar specimens had not been found in England; but the structures of these plants certainly occur in the English Coal, which, like that of Nova Scotia, rests on *Stigmaria*-underclays; and there were other instances of trees being common in the Coal-measures of Nova Scotia which were extremely rare in England; and the same discrepancies were found between different American coal-fields.

---

4. *Notes on the* GEOLOGY *of* ARISAIG, NOVA SCOTIA. By the Rev. D. HONEYMAN, D.C.L., F.G.S., &c., Director of the Provincial Museum. *With a Note by* Prof. T. RUPERT JONES, F.G.S.

[Abridged.]

In the year 1864 I communicated a paper to the Society on the Upper Silurian rocks of Arisaig and their fauna. I observed then

that these rocks were the type of a considerable proportion of the Nova-Scotian Silurian system. My field experience since then has confirmed this opinion. All the Upper Silurian rocks that I have examined appear to be repetitions of the Arisaig series, wholly or partially fossiliferous, and partially metamorphic, or highly metamorphic, and without appearance of fossils, as at Arisaig itself. I then observed, in connexion with the B, or second lowest member of my Arisaig series, "that the conditions under which it had been formed appeared to have been of a kind not the most favourable to the development of life." This statement requires modification. I have found B strata in Arisaig, and elsewhere, somewhat rich in fossils. At Arisaig Cove, south of the pier, I found, in the summer of 1868, many beautiful specimens of Orthids, Trilobites, Crinoids, and *Favosites*. In other localities I found abundance of *Lingulæ* of various species, and a peculiar fossil, singularly and beautifully milled.

I also observed, in my former paper, that A had been transformed into porcellanous jasper at Arisaig pier, Frenchman's Barn, &c.

In the summer of 1868, I found, connected with these jaspideous rocks, beds of soft material resembling silicates of magnesia, but which are now found to be silicates of alumina, which may be employed for ornamental and useful purposes.

In reference to A and B, Dr. Dawson has observed, in his 'Acadian Geology,' 2nd edition, that Dr. Honeyman had discovered strata at Doctor's Rock which appeared to be somewhat lower than his lower Arisaig, and that they were possibly on the horizon of the Medina and Oneida of the United States.

After careful consideration, I have come to the same conclusion, and regard the whole Arisaig series as equivalent to the Anticosti group. Both localities are situate in the same meridian and in opposite positions on the Gulf of St. Laurence.

To the east of the fossiliferous group of Arisaig, and in the township of Arisaig, is a band of crystalline rocks, which I discovered in the summer of 1868. These lie on the shore, and extend to some distance inland. They appear to be bounded on three sides by carboniferous rocks, the fourth side being obscure, covered by the waters of Northumberland Strait. A small patch of Lower Carboniferous conglomerate with intrusive greenstone, lying in Malignant Cove, separates these from the Upper Silurian already noticed. The whole band is peculiar and interesting; but the most remarkable feature is a broad stratum of ophiocalcite with ophiolite. The former appeared strikingly to resemble some of the ophiocalcites of the Laurentian exhibited in the Canadian Court at the Paris Exhibition of 1867. On comparing a polished specimen with a specimen of ophiocalcite from Bohemia, containing *Eozoon bohemicum*, I was almost persuaded that the Nova-Scotia specimen was Eozoonal too. I took the specimen subsequently to Montreal. Dr. Sterry Hunt, on showing it to Sir W. E. Logan in my presence, expressed the opinion "that he thought it to be Laurentian." Dr. Dawson told me that Dr. Hunt had said to him that he considered the rocks I had found to be Laurentian.

It appears that Dr. Sterry Hunt and Dr. Dawson have recently had their attention particularly directed to the specimens from Arisaig deposited in the Museum of the Geological Survey at Montreal, and they have discovered in them well-defined Eozoonal structure, which they consider as conclusive evidence of the Laurentian age of the rocks in question (see Prof. Hind's letter to Mr. Robert Roberts). I have already stated that the band is bounded on the east side by carboniferous rocks. It is still quite possible that intermediate formations may appear on the south side of the band. Where the country is exposed to the south of the band we find a considerable breadth of Carboniferous formation, consisting of conglomerates and grits largely composed of *débris* of the Laurentian rocks described, with limestone and coal-measures (*vide* Dawson's 'Acadian Geology,' 2nd edition). These are arranged in trough-shape. The conglomerates of the south side of the trough rest on the north side of an anticlinal series of metamorphic Upper Silurian, while on the south side of this anticlinal there rest conglomerates with a great band of limestones and gypsum, with a basin of gypsum clays. At Antigonish these clays are saliferous to the depth of at least 610 feet.

Note on some ENTOMOSTRACA *from* ARISAIG. By Prof. T. R. JONES.

The specimens are bivalved Entomostraca (four species) of Upper-Silurian types in three pieces of reddish fossiliferous limestone from Arisaig, with *Strophomena*, *Stenopora*, Trilobites, &c.

No. 1. Two very fine specimens of the valves, right and left, of *Beyrichia tuberculata*, Kloeden, sp. (Annals Nat. Hist. ser. 2, vol. xvi. p. 86). This may be the same form as that described by Prof. James Hall as *Beyrichia pustulosa*, 'Canadian Nat. and Geol.' vol. v. p. 158, fig. 19 (woodcut).

No. 2. Several specimens of *Beyrichia Wilkensiana*, Jones (Ann. Nat. Hist. ser. 2, vol. xvi. p. 89).

No. 3. Two valves of *Beyrichia Maccoyiana*, Jones (Ann. Nat. Hist. ser. 2, vol. xvi. p. 88), or a very closely allied species. Also a very small *Primitia*, referred to in Ann. Nat. Hist. ser. 3, vol. xvi. p. 424, as being probably the same as *P. concinna*, Jones.

This may be the form described by Prof. James Hall as *Leperditia sinuata* (Canadian Nat. and Geol. vol. v. p. 158; no figure given). This little *Primitia* is more oblong than the figured *P. concinna*, and narrower than *P. mundula*, which it otherwise much resembles: a similar form occurs in the Upper Silurian Limestone at Dudley and in Gothland.

DISCUSSION.

Sir W. LOGAN said that Dr. Hunt had seen the specimens of serpentinous limestone, and considered that they might be Laurentian. Sections of them appeared to Dr. Dawson to show tubulation rather different from that found in Laurentian *Eozoon*. They might, therefore, belong to a different age.

May 25th, 1870.

George Cox Bompas, Esq., 15 Stanley Gardens, Kensington Park, W.; Sir James Anderson, 16 Warrington Crescent, London; and John Breedon Everard, Esq., 6 Millstone Lane, Leicester, were elected Fellows of the Society.

The following communications were read:—

1. *Contributions to a knowledge of the* Newer Tertiaries *of* Suffolk *and their* Fauna. By E. Ray Lankester, B.A. Oxon., Coutts Geological Scholar.

(Communicated by Prof. Huxley, F.R.S., F.G.S.)

[Plates XXXIII. & XXXIV.]

Contents.

I. The Bone-bed of Suffolk and Stone-bed of Norfolk.

1. A definite step in the progress of the solution of the problem presented to geologists by the confused highly fossiliferous strata of the eastern part of the Eastern Counties has been made, on the one hand, in the recognition of the character of the fauna of the so-called "coprolite-" or bone-bed of Suffolk, as distinct from that of the superposed shelly strata known as Coralline and Red Crags; and, on the other hand, in regarding the fauna of the Norfolk stone-bed, first recognized by Mr. Gunn, as distinct from that of the superposed shell-beds of the Norwich Crag. The bone-bed underlying the Suffolk Crags and the stone-bed underlying the Norfolk Crags must be looked upon as having a different history and containing a quite distinct fauna from that indicated by the Mollusca of the higher beds, the two not having been contemporaneous, nor related to the same physical conditions. Until quite recently, these two distinct sets of accumulations have been confounded under the common term Crag. It is a matter for regret that the term Crag, locally applied to the shelly strata of the eastern counties, should also have been extended to the whole series of deposits of Antwerp; for whilst the upper or Yellow Crag, forming the Scaldisien system of Dumont, is clearly equivalent to our Red and Coralline Crags, the Lower or Black Crag, better called Diestien, is not represented in England by any existing strata in their true position, and is simply connected with the "Crags" by a continuity of fauna and succession, which is not so complete as to prevent a very wide and marked gap being observable between the Diestien and Scaldisien periods,—a gap indicating, probably, great change of temperature and the disappearance of remarkable marine mammalia, as well as fishes and mollusca. In England,

though no strata represent this Diestien period, yet the Cetaceans, Sharks, and shell-containing Sandstone-nodules of the Suffolk bone-bed, are the fragments rescued to us from the destruction of a vast extent of a once existing close equivalent of the Black "Crag" of Antwerp. Such remains were long confounded with those belonging to the true Crag epoch. They can now no longer be so. The term "Crag" is not applicable to the Cetaceans of the Diestien period, nor to the other contents of the Suffolk bone-bed.

The observation of the occurrence of the Suffolk bone-bed below both Coralline and Red Crags, and the recognition of the Diestien age of a large portion of its contents, first published by me in 1865, and the similar conclusion of the Rev. John Gunn with regard to the *Mastodon* and *Elephas* supposed to belong to the Norwich Crag proper (but which he has shown to be confined to a basement bed, the Norfolk stone-bed), have facilitated very considerably the comparison of the Norfolk and Suffolk shell-bearing strata. Mr. Prestwich, after detailed study of the stratigraphical and palæontological evidence, has recorded his opinion that the Norwich Crag is the true continuation northwards of the Red Crag of Suffolk. At the same time, he assigns an earlier age to the Coralline Crag, and points out a lower undisturbed and an upper disturbed portion of both Red and Coralline Crags in the Suffolk area.

The remarkably confused condition of the Red Crag in Suffolk tells a history which enables us to understand in some measure its agreement with and its differences from the Norfolk Crag. Many remarkable species of Mollusca, such as *Voluta Lamberti, Cassidaria bicatenata, Pleurotoma intorta*, &c., occur in the Red Crag, but do not appear in the so-called Norwich Crag; and no valid evidence has been adduced to support the view that they are derived from the Coralline Crag when found in the Red. At the same time, the more boreal fauna of the Norwich beds is present in the Red Crag. It is well known to collectors of the mollusca of the Red Crag in Suffolk that, superficially, they may only expect to obtain the shells belonging to the Norwich-Crag fauna, and that for the rarer forms, such as those mentioned above, they must seek in the deeper parts of the deposit and in the low-lying areas. Thus, at Waldringfield, and in the immediate neighbourhood of Woodbridge, lying on the river Deben, those species of the Red-Crag Mollusca are to be obtained which do not occur in the Norwich deposit; moreover, in these localities the valves of Lamellibranchiates are frequently found in apposition *, and small specimens of a well-marked variety of *Terebratula spondylodes* (differing from the Coralline-Crag variety), with united valves, are not uncommon. From this we may infer that the Red Crag is a deposit representing a considerable stretch of time, and that its earliest deposited beds contained a fauna differing from that which occupied the sea which at later periods, again and again, turned over and added to the accumulation. At the earlier period the Red-Crag sea contained a fauna not very different from that exhibited in the Coralline Crag, still retaining

* See a paper by Mr. Alfred Bell, Brit. Assoc. Rep. 1868.

survivors from the yet earlier Diestien epoch, viz. *Voluta*, *Cassidaria*, *Pyrula*, *Chama*, and others. In its later period, conditions had so far changed that none of these forms were remaining in the Red-Crag sea; and as it turned over the previous accumulations of shell-masses it added little thereto but boreal forms; and it was at this period and in this condition of things that the Norwich-Crag area became also the recipient of a shelly deposit, and remained apparently subject to such conditions (if we may judge by the increase of northern forms of mollusca in its higher parts) until a later period than we have evidence of in Suffolk, and when the arctic tendency of the fauna had become still more pronounced.

The Scaldisien beds, or Yellow Crag of Antwerp, do not bear evidence of quite so late a date as that of the newer element of the Red Crag of Suffolk and its equivalent in Norfolk. It appears to be entirely homotaxial with the earlier element of the Red Crag and the Coralline Crag. A closer examination of the Scaldisien fauna would be valuable at the present time.

The occurrence of large and remarkably perfect specimens of *Voluta Lamberti*, *Cassidaria bicatenata*, and *Atractodon elegans* on the beach at Felixstow in former years, together with hundreds of specimens of *Turritella imbricataria*, has never been satisfactorily accounted for. The destruction of Crag beds on the coast does not appear to be sufficient to have furnished so many specimens, although it is to be remembered that the whole of the Red Crag once existing at Harwich has disappeared beneath the sea. It does not seem improbable that these remarkable beach-specimens are the remnants of the Crag deposit which extended once towards the present Belgian coast, and which long since imbedded among other débris in the accumulations of the German Ocean, have now, by some change of current, been thrown up on the shore line.

The question as to what may be the relation of the Suffolk bone-bed and its contents to the Norfolk stone-bed and its contents is one of considerable interest and difficulty. They have this in common, that they contain the detached molars of *Mastodon arvernensis*; but the Norfolk bed also contains teeth of *Elephas meridionalis*, whilst no Elephant has ever been found in the Suffolk bone-bed*. The Suffolk bed contains phosphatized lumps of Eocene clay, with included mammalian, reptilian, piscine, molluscan, and crustacean remains of that age, also nodules of sandstone (called "box-stones") containing Diestien Mollusca, Sharks, and Cetacea, the bones and teeth of which also occur in a rolled and polished state; thirdly, teeth of *Rhinoceros Schleiermacheri*, of *Tapirus priscus*, of a peculiar *Hyæna*, of *Hipparion*, of a Trilophodont Mastodon, and of other terrestrial Mammals. None of these things have been found in the Norfolk bed;

* After the reading of this paper, Mr. Gunn exhibited a fragment of an *Elephas* molar found in a Red-Crag pit. I have a very fine specimen of the kind, and others have been recorded and deceived the late Dr. Falconer. It is easy at once to decide from their mineral condition that these specimens do not come from the Suffolk bone-bed at all, but from the large mass of overlying sandy strata.

but in their place large flints, a few bits of hardened clay, and bones and teeth of *Cervus**, *Equus*, and also *Trogontherium*. Further, it is to be remarked that the teeth of Mastodon found in the Norfolk stone-bed are not so thoroughly mineralized and so heavy as those from the Suffolk bone-bed, whilst the bones which occur in that bed are certainly by no means so heavy as those from Suffolk. The Norfolk stone-bed rests on chalk, the Suffolk bone-bed on London clay. Immediately above the Norfolk stone-bed is the Norfolk Crag, with its nearly recent subarctic molluscan fauna. Immediately above the Suffolk bone-bed is the Coralline Crag with its many extinct and tropical forms, or, where this is not present, the lower and older part of the Red Crag, or, in some places, higher sandy beds. Both stone-bed and bone-bed have, in places, been much disturbed and broken up by the sea which deposited the strata above them. Taking these facts into consideration, it is impossible to assign a simple community of origin and date to these two beds. The Suffolk bone-bed has evidently derived its contents from sources which were not accessible to the Norfolk deposit; such are the London clay and the destroyed Diestien beds. But what of the terrestrial Mammalia †? Was the *Mastodon* of the Norfolk stone-bed coeval with the *Mastodon* of the Suffolk bone-bed? If it were, we must suppose that the *Rhinoceros Schleiermacheri*, *Hipparion*, &c. of the Suffolk bed belong to an earlier age, and were not contemporary with the *Mastodon arvernensis* found with them, since in the Norfolk area these other forms are not present with the *Mastodon*. Also we must assume that the *Elephas meridionalis*, *Equus*, and *Trogontherium* of the Norfolk stone-bed belong to a later period than the *Mastodon arvernensis* found with them, since it may be positively asserted that *Elephas* does not occur in the Suffolk bone-bed. Again, there is no doubt that the terrestrial mammalian fauna (not considering here the well-identified Eocene species of *Coryphodon* and *Hyracotherium* which occur) of the Suffolk bone-bed is earlier in date than the Coralline Crag, and, perhaps, earlier than the Diestien beds which preceded that Crag, since I have obtained the tooth of a Trilophodont Mastodon from the bone-bed, with the Diestien sandstone-matrix enveloping it. This cannot be said of the Mammals occurring at the base of the Norwich Crag. All that we can assert of them is that they belong to an earlier date than the newer Crag; they are possibly not so old as the Coralline or even the earlier part of the Red Crag. The condition of the *Mastodon* teeth from the Norfolk stone-bed is decidedly one of less mineralization than that of those from the Suffolk bed, and none of them bear marks of the same extensive water-wearage which are apparent on very many from Suffolk. Moreover, the Rev. John Gunn obtained very fair evidence of the occurrence of a nearly complete skeleton of *Mastodon arver-*

* Mr. Boyd Dawkins, F.R.S., considers that there are species of *Cervus* common to the Suffolk bone-bed and the Norfolk stone-bed.

† In using the term "terrestrial mammalia of the Suffolk bone-bed" I wish to be understood as excluding the derived Eocene Coryphodonts and *Hyracotherium*. These, however, are the *only* Eocene forms which have occurred.

nensis in the Norfolk stone-bed, resting on the old chalk land-surface at Horstead, which specimen was not preserved, but of which he obtained two molars from the owner of the pit in which the bones were found.

The relative abundance of the remains of *Mastodon* in the Norfolk and Suffolk beds is important. In the Norfolk stone-bed *Mastodon arvernensis* is undeniably very much more abundant than in the Suffolk bone-bed. This was sufficiently evident before the Suffolk area had been so largely worked for the phosphatic nodules. Now that the Suffolk bed has been carefully sifted and turned over for so many acres, there is danger of overestimating the abundance of its mammalian fauna, as compared with that from Norfolk. Teeth of terrestrial mammalia are of the extremest rarity in the Suffolk bed; and it is only because of the high price offered for them, and the constant operations of the "coprolite-diggers," that so many of them have been found. Comparing equal areas of exploration, the molars of *Mastodon arvernensis* are very much more abundant in Norfolk than Suffolk. In the Norfolk stone-bed the local collectors find that *Mastodon* is about twice as abundant as *Elephas meridionalis*, whilst *Equus* and species of *Cervus* are more abundant than either.

A fact of importance with regard to the occurrence of *Mastodon arvernensis* in the Suffolk bone-bed is, that molars of this animal have been obtained from the bed with the soft bony fangs adherent, whilst in the case of nearly all other associated mammalia the enamel crowns only are found.

It is important to notice that the *bones* of terrestrial mammals are almost unknown in the Suffolk bone-bed, whilst they are abundant in the Norfolk bed. It is also necessary to bear in mind that though the Suffolk bone-bed occurs below the Coralline Crag as well as below the Red Crag, yet it has not been proved that the mammals common to the Norfolk and Suffolk beds, viz. *Mastodon arvernensis*, certain species of *Cervus* and *Equus*, are found in the bed when below the Coralline Crag. A *Mastodon* tooth which I have seen from that situation is not *Mastodon arvernensis*, but belongs to the Trilophodont species to be described below.

These, being the facts of the case, it is well simply to state the hypotheses by which we may account for the occurrence of *Mastodon arvernensis*,—in Norfolk on the one hand, associated with *Elephas meridionalis*; in Suffolk on the other hand, in most intimate connexion with Upper-Miocene mammals.

1. Seeing the very fragmentary nature of the remains found in both the Suffolk and Norfolk bone-beds, we might suppose that the absence of *Elephas* in the Suffolk bed, and of Miocene forms in the Norfolk bed, is due to imperfect knowledge of the contents of the beds, which may constitute but one fauna. This is negatived by the improbability of such an association of forms to constitute a fauna as we should then get, and by the fact that the Suffolk bed at least has been remarkably well searched.

2. Another explanation might be found in regarding *Mastodon arvernensis* as an annectant form, one which lived first with a Mio-

cene fauna and survived afterwards to bear a part in the Pliocene fauna, which is indicated by the Norfolk *Elephas meridionalis*. An objection to this is found in the absence of the *Mastodon* from the forest-bed, and from all association with *E. meridionalis* in localities north of the Val d'Arno.

3. The *Mastodon arvernensis*, certain species of Deer, and perhaps some other of the Mammalia, indicated by remains in parts of the Suffolk bone-bed, may be regarded as belonging to a later fauna than that to which the Trilophodont Mastodon (below described), the *Rhinoceros Schleiermacheri*, *Tapirus priscus*, and *Hipparion* belong. The *M. arvernensis* fauna may be supposed to have succeeded the *R. Schleiermacheri* fauna, and at the same time to have existed in Norfolk, extending to a period later, probably, than the Coralline Crag; whilst, at an earlier epoch, the Miocene mammals left their remains in the Diestien sands, which preceded the Crag, as is proved by the tooth of a Trilophodont Mastodon before mentioned. The condition of some teeth of *Mastodon arvernensis* from Suffolk, with their fangs preserved, tends to favour this view. The absence of *Elephas* from Suffolk, and its association in small proportion with the *Mastodon* in the Norfolk stone-bed, may be accounted for by granting what has been found to be true for France, namely that *Elephas meridinonalis* did not coexist with *Mastodon arvernensis*. We may suppose that the *E. meridionalis* and *Trogontherium* of the Norfolk stone-bed lived after *Mastodon arvernensis* had passed away, belonging to a distinct fauna-period, that of the *E. meridionalis*, fully represented in the forest-bed. Living on the lands which already contained remains of the *Mastodon arvernensis* in the silt of streams, in bogs, &c., these animals ultimately became associated with the past fauna in the Norfolk stone-bed. Thus we get three groups of animals or faunæ, A, B, and C, associated by the breaking up of an old land surface. B left its remains in Suffolk, which already contained the remains of A, and in Norfolk, where A's remains did not exist; C left its remains in Norfolk where B's remains existed, but not in Suffolk, which had already the remains of A and B. A is the *R. Schleiermacheri* group, B the *M. arvernensis* group, and C the *E. meridionalis* group of mammals.

The physical conditions indicated by the Diestien deposits in Suffolk, their absence from Norfolk, and the distribution of the later deposits, are apparently such as would favour the separation of the Norfolk and Suffolk areas as required in the above hypothesis.

Of the three hypotheses here offered I am inclined to the last, and though it is confessedly but a speculation, I submit that this question admits of a fair attempt at solution, and that we must not be content with the mere assertion that the bone-bed in Suffolk is a very heterogeneous assemblage of remains, and contains forms derived from the London clay as well as *Mastodon*. *Hyracotherium* and *Coryphodon* have only occurred altogether about six times in the nodules of clay from this bed; it is manifestly absurd, therefore, to speak of the London clay or Eocene beds as contributing largely to the mammalian fauna of the Suffolk Crag.

Contemporary phenomena in

Suffolk and	*Norfolk.*
1. Absent.	1. Highest Norwich Crag.
2. Later Red Crag.	2. Norwich Crag.
3. Older Red Crag.	3. Forest-bed and Elephas-meridionalis fauna of Stone-bed.
4 or 5. Coralline Crag.	4. Absent.
5 or 4. Mastodon arvernensis, Equus, and Cervus, sp., of Bone-bed.	5. M. arvernensis, and some species of Equus and Cervus, of the Stone-bed.
6. Diestien, Box-stones of Bone-bed.	6. Absent.
7. Rhinoceros Schleiermacheri, Mastodon tapiroides?, and Miocene forms of the Bone-bed.	7. Absent.
8. Eocene Beds. Coryphodon, Hyracotherium, of the Bone-bed.	8. Absent.
9.	9. Chalk.

II. The Suffolk "Box-stones."

Mr. Searles Wood has alluded to certain sandstone-nodules occurring in the Suffolk Crag and scattered on the coast, as containing shells, and being probably indurated bits of Coralline Crag. He has also figured, in the 'Supplement' to his invaluable 'Monograph of the Crag Mollusca,' the internal cast of a *Pyrula* from one of these nodules, which he terms *Pyrula acclinis.* In the 'Geological Magazine' for 1865, and in the 'Quarterly Journal' of this Society for the same year, I pointed out that these sandstone masses contain remains of Mollusca and Cetacea similar to those of the Diestien Antwerp beds, and I inferred that the nodules were remnants of a broken up deposit of Diestien age. In 1867 I devoted some time to examining these nodules, and gave a further account of them in the 'Geological Magazine' for that year (p. 91), in which I pointed out that they formed part of the Suffolk bone-bed, and lay at the base of both Red and Coralline Crags. I also gave a list of some of the organic remains found enclosed in these masses. I have since spent a good deal of time in working at the nodules, which I propose to call "Box-stones," since the name of "boxes" has been applied to those which exhibit the remains of a shell on being broken open by the phosphate-diggers of Suffolk. My friend the Rev. H. Canham, of Waldringfield, has also worked at the "Box-stones," and has kindly placed his specimens at my disposal. I must express my great indebtedness to him for the use of his valuable collection. The majority of the box-stones contain no fossil remains at all, and are simply irregular rounded masses of very much hardened sandstone. Probably not one in twenty of the masses contain any organic remains

of appreciable size. The box-stones are to be found in some quantity on the beach at Felixstow, having been washed out of the cliffs, and are also to be seen in the so-called "coprolite diggings." They occur in the "bone-bed" which is exposed in these diggings, and are picked out by the workmen, together with flints and a few other pebbles, from among the smaller phosphatized-clay fragments, and are thrown into heaps by the side of the diggings, when they are sold as "metal" for the roads. With one exception all the masses of sandstone I have seen thus picked out from the diggings have been spherical, oblong or irregular masses about the size of the fist, on an average, or sometimes of an elongated cylindrical form. The exception was in a pit at Trimley, near Ipswich, where I found four blocks of a flagstone shape about a foot and a half square, which contained casts of shells, and seemed to be identical in origin with the box-stones.

It is important to ascertain whether these "box-stones" are all of the same age, whether any of them may be masses of Eocene, or even Cretaceous sandstone. After examining a vast number of them, I believe them all to be rolled masses of the same arenaceous deposit and of Diestien age. Some of them have a very decided green tint, and vary in the darkness of this coloration. This coloration recalls strongly the black sands of Antwerp, to which it appears they are related, and is due to the same glauconitic constitution. Others of the nodules have a dark reddish-brown tint, particularly those from the sea-beach, and this change of colour is, no doubt, due to the higher oxidation of the contained iron. Lithological evidence is entirely in favour of the community of origin of these rolled masses of sandstone, the only doubtful specimens being those from the pit at Trimley above mentioned. Amongst the stones separated from the "coprolites" by the diggers, fragments of Liassic and of Cretaceous rocks are to be found, but very rarely. There is no chance, it will be admitted on inspection of the specimens, of confounding derived greensand specimens with these box-stones.

The box-stones, being of very porous constitution, are constantly subject to the action of infiltering water, and consequently those which contain shells have, with very rare exceptions, been deprived of the calcareous matter of the shell; consequently on breaking open such a "box-stone" with the hammer, a very perfect natural cast of the interior of the shell is obtained and also a concave cast of the exterior. Under these circumstances identification of the species of enclosed mollusca is exceedingly difficult; for even skilled conchologists are not apparently familiar with the appearance of internal casts of the various species which they study. A very useful plan, in those cases which allow it, I have found to consist in taking gutta-percha impressions of the concave casts; in this way a perfect restoration of the original shell is obtained, and conclusions formed from the internal casts may be corrected. In this way I have got very beautiful impressions of a *Conus* (Plate XXXIV. fig. 5) (first observed by Mr. Searles Wood in these nodules), also of a small *Cassidaria* (Plate XXXIV. figs. 8, 9), which has been hitherto regarded

as *Nassa conglobata*, on account of the deceptive appearance of its internal cast (a specimen is thus named in the British Museum). Mr. Searles Wood's *Pyrula acclinis* is shown, by the impression taken from the concave cast of similar specimens, not to have a more elevated apex than *P. reticulata*, a character which he was led to attribute to it from the deceptive appearance of the internal cast. The specimens of the box-stones and gutta-percha impressions have been placed in the museum of the Society.

The additional facts which I have gathered relative to these nodules since 1867 tend to confirm the conclusion then maintained, viz. that they are of Diestien age, *i. e.* approximately equivalents of the so-called Black Crag of Antwerp. It also appears very probable that they are of the same age as the Lenham sandstones, which they resemble most closely in condition and contents.

The box-stones of the Suffolk bone-bed represent a period separated by a wide gap from the Red and Coralline Crags, between which and the latter, or true-crag period, the numerous ziphioid and other cetaceans, the great sharks and *Trichecodon*, had passed away; a few of the mollusca, such as *Voluta*, *Pyrula*, and *Cassidaria*, comparatively abundant in these nodules, still lingered on into the Coralline and Red-Crag period, but attained a larger size, recalling the fact observed with living mollusca, that northern specimens of a species are larger than those from more southern regions.

The most important organic remains which I have found in the Suffolk box-stones, or with the sandstone adherent, may be now mentioned; a list is given below. Mr. Baker, of Woodbridge, has the left upper penultimate molar of a Trilophodont Mastodon with this sandstone adherent. Teeth of Ziphioids and fragments of cetacean bone are also found included in this way. The largest tooth of *Carcharodon* which I have seen from Suffolk is one which I obtained from a "digger," and has the box-stone matrix adherent. *Pectunculus glycimeris* is the most abundant mollusk, and next to that *Isocardia lunulata* (Plate XXXIV. fig. 10), the casts of which I have compared with casts from Antwerp specimens. It will be remembered that *Isocardia*, though very rare indeed in the English crags, is an abundant shell in the Antwerp Diestien beds. *Pyrula reticulata* is by no means uncommon amongst the Gasteropods, far more abundant than in the English Crags. Two specimens of a *Conus*, identified by Mr. Searles Wood with *Conus Dujardinii*, one found by the late Mr. Acton, the other by the Rev. H. Canham (Plate XXXIV. fig. 5), are the most distinctive mollusks yet obtained in the nodules. Altogether about 36 species of organic remains have been found at present in the box-stones; though I cannot say that all these species have been satisfactorily identified. The specimens are placed in the Society's cabinet, and through their further examination it will be possible to fill in the list more completely.

In the collection of Mr. Whincopp is a crocodilian scute imbedded in this sandstone; it is clearly of Eocene age, and shows that the destruction of Eocene strata and admixture of their contents had commenced at this period of the history of the East-Anglian area.

I must particularly guard against the inference from this specimen that any of the sandstone-nodules are of Eocene age; the scute is water-worn, and its occurrence in the sandstone is sufficiently explained as above.

List of Organic Remains from the Box-stones.

Vertebrates.

1. Trilophodont Mastodon. (Pl. XXXIV. figs. 1–4.)
2. Ziphioid teeth.
3. Carcharodon megalodon (tooth).
4. Oxyrhina (tooth).
5. Crocodilian scute (derived from Eocene beds).

Mollusca.

6. Conus Dujardinii (?), 2 specimens. (Pl. XXXIV. fig. 5.)
7. Voluta Lamberti, rare.
8. Voluta auris-leporis, 1 specimen. (Pl. XXXIV. fig. 6.)
9. Pyrula reticulata, more abundant than Voluta.
10. Cassidaria, sp., rare (8 specimens). (Pl. XXXIV. figs. 8, 9.)
11. Trochus ziziphinus, 2 specimens.
12. Trochus, sp., 1 specimen.
13. Natica, sp., 1 specimen.
14. Natica, sp., 2 specimens.
15. Turritella, sp., not rare.
16. Bulla, sp., not rare.
17. Trophon, sp., rare.
18. Trophon, sp., rare.
19. Nassa?, rare.
20. Dentalium, sp. (costatum?), not rare.
21. Pectunculus glycimeris, abundant.
22. Isocardia lunulata, not rare. (Pl. XXXIV. fig. 10.)
23. Panopæa, sp. (Faujasii?), not rare.
24. Mya, sp.?, not rare.
25. Cyprina islandica, rare.
26. —— rustica, rare.
27. Venus (large sp.), 1 specimen. (Pl. XXXIV. fig. 7.)
28. Glycimeris angusta (sp.?), 3 specimens.
29. Astarte sulcata, 2 specimens.
30. Pecten opercularis, rare.
31. Pecten (small sp.), not rare.
32. Cardium decorticatum, not rare.
33. Cardium venustum, 1 specimen.
34. Abra, sp., not rare.
35. Tellina, sp., rare.

Cirrhipede.

36. Balanus inclusus, 1 specimen.

Vegetable.

37. Wood (exogenous), not rare.

III. A NEW ZIPHIOID CETACEAN FROM THE SUFFOLK BONE-BED (*Choneziphius Packardi*). Pl. XXXIII., figs. 1–4.

The fossil about to be described was found lying by the side of a crag-pit near Felixstow, Suffolk, and was for many years in the collection of the lady after whom *Nucula Cobboldiæ* was named. It has lately been presented by Mr. Cobbold, with some other fossils, including a wonderfully fine specimen of *Pleurotoma intorta*, to the Ipswich museum, that institution having during the past year, through the exertions of Mr. Edward Packard, Mayor of the town, been much enlarged and extended in its series of crag fossils. Mr. Packard has given some very valuable specimens from his own collection to the museum, besides contributing largely to the expense of arranging the collection and filling up gaps in the suite of crag mollusca.

The specimen is exceedingly heavy, and is in precisely that mineral condition which characterizes the cetacean bones from the Suffolk bone-bed, and which demonstrates them to have lived, not in the crag sea (the proper cetacean remains of which are pulverulent, as I pointed out in the Quart. Journn. Geol. Soc. 1865, p. 223), but

in the preceding Diestien epoch, the breaking up of the accumulation of that period having furnished the numerous cetacean remains, the box-stones, and the phosphatic properties to the Suffolk bone-bed.

Like other ziphioid snouts and bones from this bed, the specimen bears the marks of terminated *Pholas*-borings. The mollusks appear to have penetrated the matrix which once surrounded the fossil, and to have been stopped by the peculiar properties of the dense bone.

The specimen is $16\frac{1}{2}$ inches long; anteriorly it is complete, posteriorly it is broken at the same point as are all the ziphioid snouts from this bed, viz. in a plane corresponding with the anterior boundary of the nasal orifice above, and below with the junction of the palatine and maxillary bones. The solid fragment or rostrum which is preserved consists therefore of the maxillary, intermaxillary (the expanded portion being imperfect), and vomerine bones.

It is much broader posteriorly than anteriorly, measuring $6\frac{1}{2}$ inches at its posterior limit and tapering gradually from that to a subacute anterior termination.

Seen from above (Pl. XXXIII. fig. 2) it is somewhat flat, rising a little into convexity anteriorly and considerably raised at the posterior margin round a deep and wide fossa (*x r g*), which is excavated in this part of the surface in connexion with a superficial groove (*r g*).

Seen from below (Pl. XXXIII. fig. 1) it is considerably arched, being highest posteriorly and elevated into a marked keel in the posterior third of the middle line, which is continued into a prominent vertical ridge, projecting from the posterior surface of the specimen. The lateral angles are also produced, so that the posterior region presents a trifid appearance. The keel spreads out anteriorly into a wide convex area marked out on either side by a ridge. Two lateral ridges on either side also run from behind forwards, passing somewhat obliquely towards the inferior surface as they proceed. The superior and most prominent of these probably marks off the maxillary from the intermaxillary component of the rostrum. The most important feature presented by the inferior surface of the rostrum is its rather sudden approximation to the superior surface anteriorly, so that in profile (Pl. XXXIII. fig. 3) it appears to bend upwards like the bows of a boat, whilst a small portion (the most anterior) of the rostrum projects again forward from this like a bowsprit. Below and posteriorly to this most anterior part of the rostrum is a cavity $\frac{3}{4}$ of an inch in diameter, extending axially to the rostrum (Pl. XXXIII. figs. 1 & 3, *v c*), the "remains of the primitive trough-like cavity of the vomer" as Professor Huxley calls it in describing *Belemnoziphius*.

Seen in profile (Pl. XXXIII. fig. 3), the whole rostrum is not unlike the roughly cut hull of a sailing-vessel, with flat deck, keel below, tapering bows, and square stern of exaggerated breadth.

The canals which are present in this rostrum, besides the axial vomerine canal, transmitted vessels, and nerves, are of the same nature as those seen in rostra of *Belemnoziphius*; at the same time they have not an exactly similar disposition. The fractured posterior superior border of the specimen presents on each side of the middle vertical ridge, more or less completely according to the degree

of fracture, a pair of canals (four in all). One of these canals (Pl. XXXIII. figs. 2, 3, & 4, *i l*) (on each side) is a little wider than a common lead-pencil and is exposed at the extreme lateral points of the rostrum, running thence downwards and forwards for a few inches, when it receives the other canal (the two sides corresponding), which is smaller and has a superior position (*s l*). The smaller canal has its posterior termination (caused by fracture which has destroyed more of the left than of the right of these smaller canals) within an inch and a half of the median line and on the superior part of the specimen, so that it is not impossible that the canals *a*, *a*, of Huxley ("On a New Cetacean," Quart. Journ. Geol. Soc. vol. xx. pl. xix., 1864) are represented by this pair. The course of each small canal is forwards, outwards, and downwards to meet the larger lateral canal, which it joins at an acute angle. After the junction of the smaller postero-superior canals with the large lateral canals, these continue to run forwards and inwards, as a lucky split in the specimen, which allows a piece of the rostrum to be removed, enables one to see, with regard to the left side; their ultimate course is not, however, traceable. At the point where the larger canal receives the smaller one on this broken side, four slightly diverging smaller canals are given off, which run forward in the substance of the rostrum and probably transmitted vessels; one of these occupies the position in which Prof. Huxley describes a lateral groove finally becoming a covered canal in *Belemnoziphius*, viz. along the line of the lateral ridge which marks off the maxillary from the intermaxillary region of the rostrum. In this specimen the canal of neither right nor left side becomes a groove externally; but that on the left side has a small terminal opening anteriorly, though none can be traced on the right side. Some of these small branches of the large lateral canals, in a measure, represent the pair seen in the transverse section of the anterior portion of the rostrum of *Belemnoziphius* (see Prof. Huxley's fig. D), which are also present and open externally in *Choneziphius*. How far this system of canals agrees with those of the *Choneziphius planirostris* of Cuvier it is impossible to say, without examination and perhaps section of actual specimens, since the cast in the British Museum of a specimen (not of the original, which is preserved at Paris) does not show either the canals or their orifices. The two fragments of *Choneziphius* in the British Museum, from Suffolk, are not sufficiently perfect to be of use.

The longitudinal fracture of the left side of the rostrum, which shows something of the disposition of the canals in the middle part of their course, also demonstrates the solidity and density of the structure. It further shows that the keel, described as marking the posterior third of the inferior surface, is continuous with a central mass of bone reaching forward from it, and from which the detached piece has become separated along a kind of surface of anchylosis. This central ridge, appearing posteriorly as the keel, is the vomerine constituent of the rostrum, which is closely embraced by the maxillaries and intermaxillaries, welded and soldered to it without any superficial indication, such as a suture or groove.

The superior surface of this specimen does not present the complete pair of grooves which run along the superior surface in *Belemnoziphius*, enclosing between them a central vomerine area; nor, like typical *Choneziphius planirostris*, does it present a bifid structure in the presence of a central groove stretching from the orifice of the vomerine canal; on the contrary, the curious projection of the anterior end of the rostrum (which is paralleled in some specimens of *Belemnoziphius*) overhangs and conceals the vomerine canal, and the surface is perfectly smooth, neither indicating the junction of the intermaxillaries by a median fissure, as in *Choneziphius planirostris*, nor allowing the vomer to appear between those bones, as in *Belemnoziphius*.

The large unsymmetrical fossæ excavated in the expanded portion of the intermaxillaries at the posterior part of the specimen lead into short grooves, which run forward on the surface and soon dwindle away (Plate XXXIII. fig. 2, *l g* and *r g*). These are identical with the grooves demarcating the vomerine tract in *Belemnoziphius*; but here they terminate rapidly, as in *Choneziphius*, by the junction of the intermaxillaries in the middle line. They are present in *Choneziphius planirostris*, which has similar fossæ to those seen in this specimen; but in Cuvier's first specimen the grooves are for a short space converted into canals, whilst in another specimen of *Choneziphius planirostris*, of which there is a cast in the British Museum, the canals are as open as in this specimen.

Generic position and species.—The rostrum under description clearly does not belong to Professor Huxley's genus *Belemnoziphius*, which is remarkably well characterized not only by the solidity of the rostrum, the complete exposure of the central vomerine area (which Professor Owen, differing from Cuvier, Duvernoy, Gervais, and Van Beneden, terms prefrontal), but also by the two obvious perforations placed near the middle line in the intermaxillaries on the anterior wall of the nasal fossa marked *a a* by Professor Huxley in his figure of *Belemnoziphius compressus*.

The series of canals in *Belemnoziphius* and *Choneziphius* differ in a very marked manner; but it is not possible to determine their exact relations without detailed comparison, and perhaps cutting specimens. Recently in Paris I had the opportunity, by the kindness of M. Gervais, of examining carefully the rostra of Cuvier's types of *Z. planirostris* and *Z. longirostris*. *Z. longirostris* (*Belemnoziphius*) comes very near to the Seychelles *Ziphius* (*M. densirostris*), and differs remarkably, as do all our Crag *Belemnoziphii*, from *Choneziphius* in the absence of the large unsymmetrical fossæ seen in the latter genus, and in the presence of the sharply marked orifices leading into a canal (*a a* of Huxley's paper), which is absent in the other. Professor Owen marks these structures as identical in his recent monograph; but they have a distinct character, though possibly related in origin. It is not possible to fully compare the canals of *Belemnoziphius* with those of *Choneziphius*, on account of the loss of the expanded portion in all specimens of the former genus. The specimen which best shows the proximal part of the rostrum of

Belemnoziphius is that numbered 27432 in the British Museum; it is more complete than Cuvier's specimen of *longirostris*. There is no doubt that the new ziphioid rostrum from Suffolk belongs to the genus *Choneziphius* as amended by Huxley. It differs from the described specimens of *Ch. planirostris*, and from a small cast (not of the type specimen) in the British Museum, in the pointed termination of the rostrum, a solid bit projecting beyond the axial cavity

Fig. 1.—*Skull of* Choneziphius planirostris.

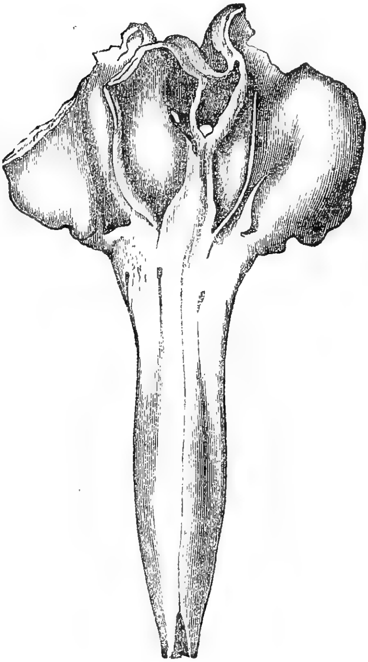
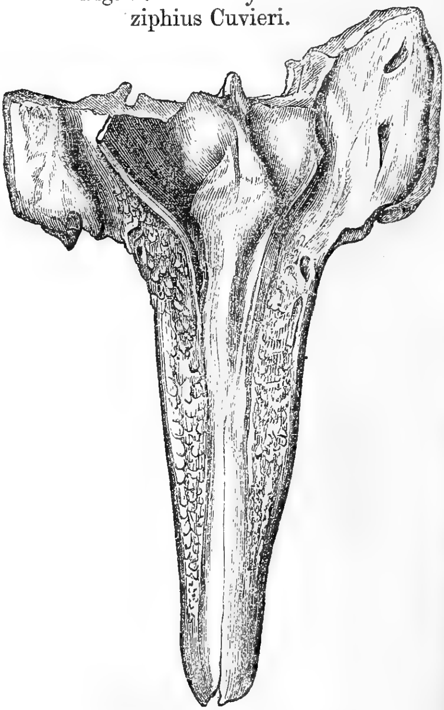


Fig. 2.—*Skull of* Choneziphius Cuvieri.



in place of its presenting a bifid termination; also the outline is much thicker and less cylindrical than in the cast alluded to. I was, however, surprised to find, in comparing Cuvier's two specimens of *Ziphius planirostris* and a cast of a third in Paris, that great differences in these particular characters of the rostrum existed. Cuvier's second specimen has recently been called *Z. Cuvieri* by Professor Owen; and as it is perhaps useful to distinguish the various forms, I propose to call this from Suffolk *Choneziphius Packardi*, in honour of my friend the liberal and excellent Mayor of Ipswich. It comes nearest to *Ch. Cuvieri* of the three specimens which are in the Museum of the Jardin des Plantes, since the general outline

agrees best with that, as well as the solid termination of the rostrum. But it is perhaps a legitimate question as to whether the forms of *Choneziphius* represented by Cuvier's first specimen, by his second, by the cast sent by Prof. Van Beneden to Paris of a third, by the small cast in the British Museum, and finally by this new Suffolk specimen are not all varieties of age and sex of one species. *Hyperoodon* is known to be exceedingly variable in the characters of the rostrum within the limits of the same species, and so perhaps were the fossil ziphioids. If this is not the case it is very strange that nearly every new specimen of a ziphioid rostrum which turns up baffles all attempts at finding its counterpart, and requires a new specific name. *Choneziphius Packardi* stands certainly at one end of the series, the other extreme being represented by the small cast of *Choneziphius* in the British Museum. Woodcuts of Cuvier's *Ziphius planirostris* (fig. 1) and of *Z. Cuvieri* (fig. 2) are here given for the sake of comparison with the plate*.

I would direct the attention of those who are interested in the study of fossil Cetacea, and who have seen the Monograph of Crag Cetacea lately issued by the Palæontographical Society, to a paper published by me in 1867 on the structure of the tooth of *Micropteron Sowerbiense*, in which I described the nipple-shaped tooth of *Z. Layardi* and *Berardius Arnuxii*, as well as that of the tooth specially treated of, and drew certain conclusions as to the character of recent and fossil ziphioid teeth, which are now set forth afresh, without reference to that paper, by Prof. Owen; so, too, the views which I first advocated in this Journal as to the Diestien character of the Crag Cetacea are adopted without acknowledgment of any kind, though widely differing from Professor Owen's former views.

It should be remarked that the numerous sections of rostra given in the recent Monograph are purely imaginary, and that the separation of the bones marked 14 and 15 therein is hypothetical. Whilst no generic divisions of *Ziphius* are recognized, the specific name applied some years since by Prof. Huxley to a *Belemnoziphius*, namely "*compressus*," is taken by Professor Owen without any explanation, and applied as his own to another species. As a reply to assertions on the last page of the Monograph, I am glad to be able to mention here that I *have* obtained a Cetacean tooth of the Zeuglodont type from Suffolk. I mentioned its occurrence in the 'Geological Magazine' (1868); it is probably one of the foliaceous molars of the *Squalodon antverpiensis* of Van Beneden and Gervais.

IV. The Trilophodont Mastodon of the Suffolk Bone-bed (Plate XXXIV. figs. 1–4).

In the 'Geological Magazine' for 1869, I briefly noticed the occurrence of a trilophodont Mastodon in the Suffolk bone-bed, having observed an upper penultimate molar in the collection of Mr. Baker, of Woodbridge, which indicated such a form. This specimen is drawn

* I have to thank the authorities of the Palæontographical Society for the loan of these figures.—E. R. L.

in Plate XXXIV. fig. 1. During the past year I have examined the collections of Mr. Whincopp, of Woodbridge, of the Rev. H. Canham, of the Mayor of Ipswich, of the Ipswich Museum, of Mr. MacLean of Yarmouth, of Mr. Roper of Lowestoft, of the British Museum, and others less extensive, with the view of obtaining further evidence as to this new British Mastodon. The result has been that in Mr. Whincopp's collection I observed two fragments consisting of two constituent ridges of a mastodont molar quite distinct from *M. arvernensis*. In the collection of Mr. Canham I found three fragments, two of which are here figured (Pl. XXXIV. figs. 3, 4), one of which is very similar to those belonging to Mr. Whincopp; in the British Museum three similar fragments were detected with the aid of Mr. Davis, one (no. 27850) consisting of $2\frac{1}{2}$ ridges, two others (28994 and 28253) being terminal ridges with a talon like that in the figure. These eight fragments do not furnish evidence of the Tetralophodont or Trilophodont character of the teeth from which they came; but they agree in important characters with the thoroughly typical three-ridged molar belonging to Mr. Baker. In the collection of Mr. Roper, of Lowestoft, I observed a much worn Mastodon molar presenting but three widely set ridges; and a similar specimen was purchased by Mr. Charlesworth at Felixstow in the summer.

The perfect molar* of Mr. Baker, and the fragments since observed, belong to that form of Mastodon tooth which is furthest removed from that of *M. arvernensis*, the only Mastodon hitherto known in the Suffolk bone-bed. In place of the complicated interrupted valleys of that species, we have wide and clear valleys with simple primary transverse ridges, such as *Mastodon ohioticus* presents.

Mastodon Borsoni, which presents free valleys and a three-ridged structure of the penultimate and anterior molars, is found in association with *Mastodon arvernensis* in Central France; hence it is not improbable, *primâ facie*, that the new Crag *Mastodon* belongs to that species. A close comparison of specimens is, however, difficult, for we have no specimens of molars of *M. Borsoni* in the public collections of this country, and moreover the material at present obtained from the Crag is scanty. It is unfortunate (though of exceeding interest from another point of view) that the valleys in Mr. Baker's otherwise perfect specimen are occupied by a sandstone matrix, that of the Diestien "box-stones," which cannot be removed; hence the character of the transverse valleys in this specimen is not quite clear. Mr. Canham's and other specimens, however, show perfectly simple valleys, agreeing with those of *Borsoni*, with one exception, the fragment drawn in Pl. XXXIV. fig. 4.

If not *M. Borsoni*, the only other species which the new Suffolk

* M. Lartet, of Paris, has expressed to me doubts as to the complete character of the specimen, after inspecting a cast of the upper surface, and would look upon it as a fragment of an ultimate molar of *Tetralophodon longirostris*. I must, therefore, insist especially on the fact that this is a *perfect* enamel crown, of three ridges; and my friend Mr. George Busk, F.R.S., than whose no better opinion can be found, authorizes me to state that this is his opinion also, after careful examination of the specimen.

Mastodon is likely to be is the Miocene *M. tapiroides* (*M. turacensis*, Pom.), which also belongs to the Trilophodont section, and has simple valleys. The molars of *M. tapiroides* have a very marked cingulum, and are broader than those of *M. Borsoni*; whilst the ridges are not so high relatively as in that species. A small oblique plication running vertically on the sides of the transverse ridges is, however, considered by M. Lartet (Bull. Soc. Géol. France, 1859) its most distinguishing feature. Now, Mr. Baker's molar (Pl. XXXIV. figs. 1 & 2) has shorter ridges than *M. Borsoni*, is wider than specimens of the corresponding tooth of *M. Borsoni* which I examined in Paris and in Le Puy, and has a considerable development of cingulum, which, though not nearly so large as that of *M. tapiroides* is yet larger than any presented by *M. Borsoni*. At the same time, Mr. Baker's specimen, and all the fragments except that drawn in fig. 4, have no trace of the oblique vertical fold characteristic of *M. tapiroides*. A decided indication of this fold is, however, present in Mr. Canham's fragment drawn in fig. 4 (*t r*), and it is a question how far this is decisive of a specific relation to *M. tapiroides*. We have not at present the material for deciding the question, though this particular fragment (fig. 4) is referable to that species. M. Lartet, however, informs me that he has seen from other localities evidence of a form intermediate between *M. tapiroides* and *M. Borsoni*, and the specimens from the base of the Crag may belong to such a form. The posterior talon seen in figs. 1 and 2 is also preserved in the two specimens in the British Museum, and has a very constant form.

All the specimens of this Trilophodont form, excepting Mr. Baker's, are mere fragments, and most are much water-worn, which is significant of their history, and contrasts strongly with the condition in which the teeth of *Mastodon arvernensis* occur; so much so that one is not disposed to regard the two species as certainly contemporary. The fragments and water-worn bits of Rhinoceros-teeth may be more consistently associated with this new Mastodon; and on the whole it seems probable that we must assimilate this new *Trilophodon* to the Miocene rather than the Pliocene species.

I am aware that Mr. C. B. Rose some years since obtained a fragment of a Mastodon-tooth from gravel-beds, which he considered to be *M. Borsoni*; but the specimen and its history appear to be too imperfect to throw any light on the Trilophodont species from the Suffolk bone-bed, one specimen of which, be it remembered, is of pre-Diestien age.

V. List of Species of Terrestrial Mammalia from the Suffolk Bone-bed, with reference to the number of Specimens and the Collections containing them.

There is, and has been for some years, in that district of Suffolk where the so-called "coprolites" are dug, a remarkable eagerness to obtain and preserve the teeth of *Mastodon* and other mammals found in the bed. Very high prices are given for these teeth (in some cases several pounds), and accordingly many of the most interesting

specimens are in local private collections. The following list may give some assistance to any person wishing to come at the material relating to any one of these mammalian forms which yet requires working out. *Coryphodon* and *Hyracotherium*, the teeth of which occur in this bed, are excluded from consideration, since they are clearly of an earlier age than the other forms, and are in a different mineral condition. The late Dr. Falconer mistook a coryphodont molar in the British Museum (no. 27432), from the Suffolk bone-bed, for the premolar of *Mastodon arvernensis*. All the mammalian remains about to be enumerated are in one and the same mineral condition, having a peculiar gloss and weight; in most cases the enamel crowns only of the teeth occur, the bony fangs having been destroyed. In some carnivorous teeth, and in two *Mastodon*-teeth, I have seen the fangs preserved. No bone which could be identified with any of the teeth has ever been found in the bed. The species are placed in order of abundance.

1. *Sus*, sp. Molars of every size are to be met with. Mr. Whincopp, Mr. Canham, and Mr. Baker have the best specimens. Mr. Whincopp has a large imperfect canine.

2. *Rhinoceros Schleiermacheri*, Kaup. Fragments of Rhinoceros-teeth are abundant in collections; perfect specimens very rare, especially specimens of the posterior upper true molars; Mr. Whincopp has two such molars; Mr. MacLean, of Yarmouth, has one. Anterior upper molars are not so rare; there is one in the British Museum, and two or three more or less perfect in the Ipswich Museum, in Mr. Whincopp's, Mr. Baker's, and Mr. Canham's cabinets. Lower molars in a perfect state (as far as the crown is concerned) are more common.

It is well ascertained that some of these teeth belong to *R. Schleiermacheri*, but it has been suggested that there are indications of *R. etruscus* and of *R. megarhinus*. It is most desirable that this point should be cleared up as far as possible.

3. *Tapirus priscus*, Kaup. Specimens of molar-crowns of Tapir, more perfect than that on which Prof. Owen based his identification of the Suffolk form with Kaup's *T. priscus*, and from various parts of the molar series are in Mr. Whincopp's and Mr. Baker's collections. The Rev. H. Canham, of Waldringfield, has the finest series,—six well-marked specimens. The Tapir-teeth are certainly of the same age as the Rhinoceros-teeth, if we may infer any thing from identity of mineral condition and colouring.

4. *Mastodon* (*Tetralophodon*) *arvernensis*, Croizet and Jobert. Very fine ultimate molars are—one in the Ipswich Museum, presented by Mr. Packard, another at York, in Mr. Reed's collection; Mr. Whincopp has no perfect large specimen, but a beautiful milk-molar; Mr. Baker has a series of seven, nearly all perfect teeth; Mr. Canham has two very perfect penultimate upper molars, one with the fangs attached; in the British Museum is a perfect crown of the lower ultimate molar and some fragments. Altogether there cannot have been taken out of the Suffolk bone-bed more than thirty perfect or nearly perfect molars of *Mastodon arvernensis*. The only

specimens of tusks from the bed are one fragment in the British Museum, and one very small fragment in Mr. Whincopp's collection.

5. *Cervus*, sp. The teeth and horns of Cervine animals from this bed are abundant in collections, and indicate several species, which cannot be considered as having been at all satisfactorily determined. Portions of jaw with teeth *in situ* are occasionally found. There is such a specimen in the British Museum. The collections already mentioned contain each a few specimens which are important in attempting to work out the *Cervi* of this deposit. Mr. Canham has two fine molars of the large form, which was assigned by Professor Owen to *Megaceros*. Each of these collections contains also one or two teeth of

6. *Hipparion*, sp.

7. *Equus*, sp.

8. *Castor veterior*, Lankester, figured by me in the 'Annals and Magazine of Natural History,' 1864, is represented by two molars and an incisor in Mr. Whincopp's collection.

9. *Ursus arvernensis*, Croizet and Jobert, is represented by a single canine in Mr. Whincopp's collection.

10. *Felis*, sp. Besides the fragment of a molar figured by Prof. Owen in the 'British Fossil Mammals' as *Felis pardoides*, and now in the Ipswich Museum, I have observed in Mr. Canham's collection a very perfect upper last premolar of a feline animal of the same size, also a similar tooth, more worn, in Mr. Baker's collection. These teeth have the fangs preserved.

11. *Hyæna antiqua*, Lankester. Three specimens now represent this species, indicated by me in the 'Annals and Magazine of Natural History,' 1863,—one upper third premolar now in the British Museum, for which collection I purchased it at Felixstow; one lower third premolar in Mr. Whincopp's collection, much worn; lastly a very perfect specimen of another upper third premolar like the first, of a much deeper stain, however, and somewhat more mineralized, in the collection of Mr. Baker at Woodbridge (Pl. XXXIII. figs. 5, 6).

12. *Mastodon* (*Trilophodon*) sp. (*tapiroides?*, Cuvier). Perfect enamel crown of left upper penultimate molar in the collection of Mr. Baker of Woodbridge; fragments in Mr. Whincopp's, Mr. Canham's, and the British Museum collections.

The preceding paragraphs will give some notion of the fragmentary character of these remains, which would never have been known at all but for the careful sifting for phosphatic nodules of the bed in which they occur.

VI. List of Marine Mammalia from the Suffolk Bone-bed, with reference to the number of Specimens and the Collections containing them.

1. *Trichecodon Huxleyi*, Lankester. Fragments of the tusk of this species are in nearly all collections. The finest I have seen are in Mr. Whincopp's and Mr. Baker's collections, who have portions of the base more than a foot long.

In the 'Bulletins of the Belgian Academy for 1867,' vol. xxiv. p. 566, the Vicomte Du Bus describes this form, a fragment of the tusk of which Prof. Van Beneden showed me from the Diestien beds in 1864, as *Alachtherium Cretsii*. The description is short, and no figure is given; my *Trichecodon* is, however, clearly the form described, and the name *Trichecodon Huxleyi* has precedence by three years.

2. Teeth of Ziphioids. Abundant in all collections; species undetermined.

3. Teeth of other large Cetaceans; undetermined.

4. Ear-bones of *Balæna* and other Cetaceans, including *Delphinus*, not determined satisfactorily. Specimens of great beauty are in Mr. Whincopp's collection, and would admit of identification.

5–12. Rostra of *Belemnoziphius*, seven species named. Besides those with MS. names in the British Museum, the collections of Mr. Whincopp, Mr. Canham, and Mr. Baker contain specimens (especially the first-named collection) which probably belong to yet other species, and are more perfect than those which have been named.

13. Rostra of *Choneziphius planirostris*, Cuvier. A fine specimen in Mr. Whincopp's collection; one in the possession of Mr. Calvert, of the Strand; two fragments in the British Museum.

14. Rostrum of *Choneziphius Packardi*, Lankester, in the Ipswich Museum; also a less perfect *Choneziphius* in my collection, perhaps *Ch. Cuvieri* of Owen.

15 and 16. Teeth of *Delphinus*. A few in the three principal collections, of probably two species.

17. *Squalodon*. Long cylindrical teeth, probably referable to this genus, are in collections (see fig. Geol. Soc.). A single foliaceous tooth (of the Zeuglodont type of Owen), undoubtedly belonging to *Squalodon*, probably *S. antverpiensis*, is in the Rev. H. Canham's collection.

EXPLANATION OF PLATES XXXIII. & XXXIV.

[*All the figures, excepting those of* Choneziphius, *are of the natural size.*]

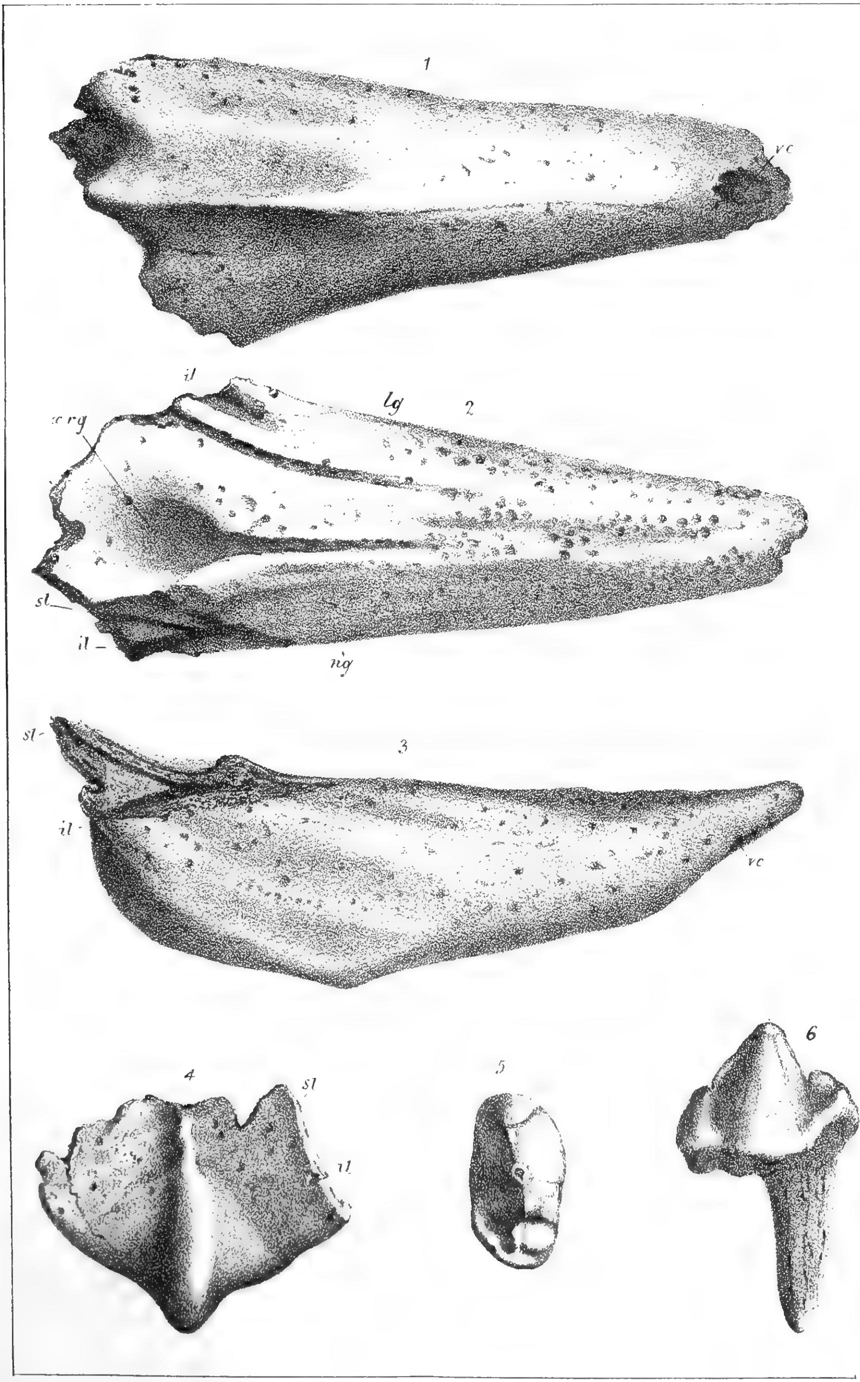
Plate XXXIII.

Figs. 1–4. Four views of the rostrum of a new Ziphioid Cetacean (*Choneziphius Packardi*) from the Suffolk Bone-bed, near Felixstow, in the Ipswich Museum, presented by Mr. Cobbold. The figures are reduced to one-fourth the natural size, linear; consequently they do not give an adequate notion of the large bulk and solidity of the specimen, which measures 16½ inches in length.

Fig. 1, viewed from below; fig. 2, viewed from above; fig. 3, viewed from the right side; fig. 4, viewed from behind.

v c, primitive trough-like cavity of the vomer; *l g*, left groove of the dorsum; *r g*, right groove of the dorsum; *x r g*, expansion of the right groove of the dorsum; *s l*, superior lateral canal (one on either side); *i l*, inferior lateral canal (one on either side).

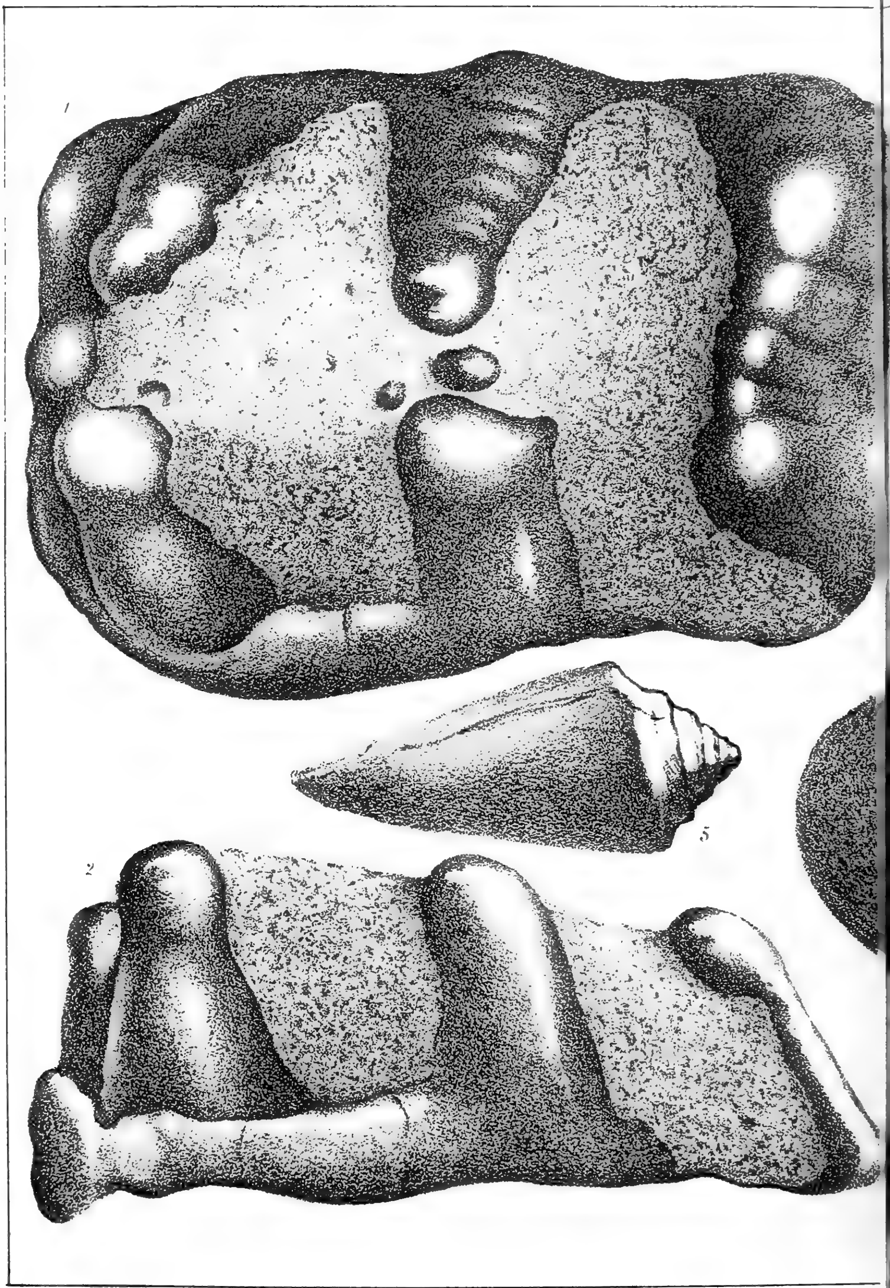
Figs. 5 & 6. Third upper premolar of the right side of *Hyæna antiqua*, from the Suffolk Bone-bed, in the collection of Mr. Baker, of Woodbridge. (Compare the figures of the two other specimens in the 'Annals and Magazine of Natural History' for 1864, ser. 3, vol. xiii. pl. viii., and vol. xiv. pl. viii.)



De Wilde lith.

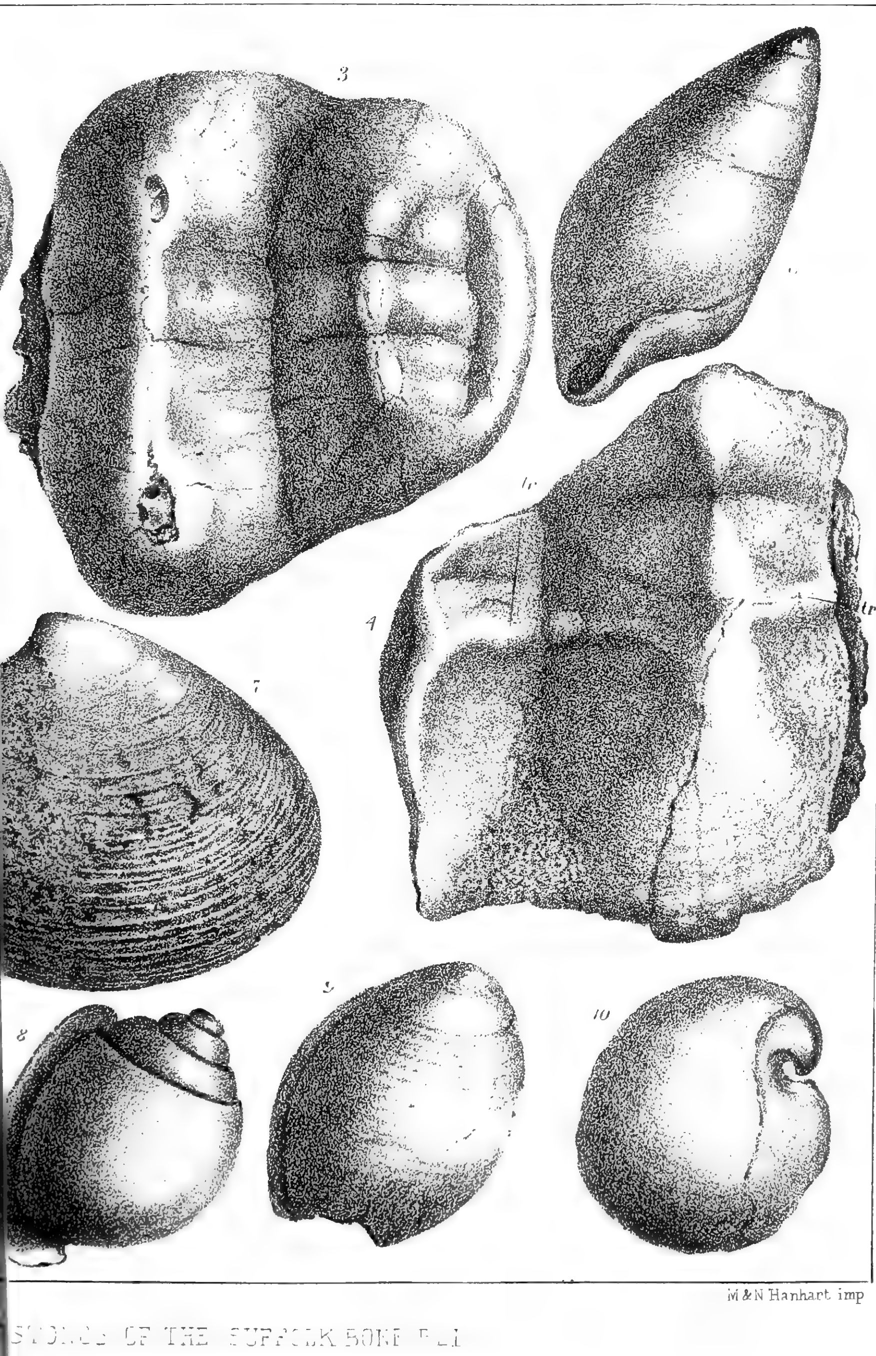
M & N. Hanhart, impᵗ

CHONEZIPHIUS PACKARDI & HYÆNA ANTIQUA.



De Wilde Lith.

FOSSILS FROM THE DIESTIAN NODULES (B



M & N Hanhart imp

STONES OF THE SUFFOLK BONE BED

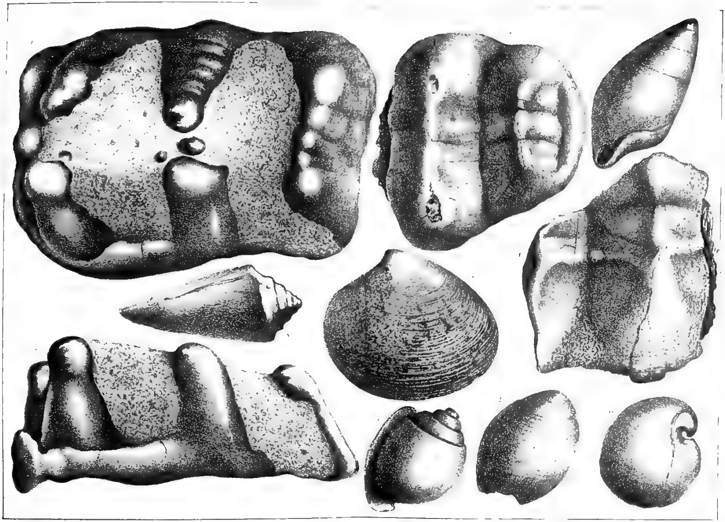


Plate XXXIV.

Figs. 1–4. New *Mastodon* from the Suffolk Bone-bed.

Fig. 1. Enamel crown of a left upper penultimate molar of a Trilophodont Mastodon, with simple valleys between the primary ridges, from the Suffolk Bone-bed. Diestien matrix fills up the valleys. In the collection of Mr. Baker, of Woodbridge.

Fig. 2. Side view of the same tooth.

Fig. 3. Fragment consisting of two terminal ridges of a similar tooth, probably a lower molar, from the Suffolk Bone-bed. In the collection of the Rev. H. Canham, of Waldringfield.

Fig. 4. Fragment of another tooth, exhibiting a slightly oblique secondary transverse ridge or fold of enamel (*t r*) crossing the valley, and hence similar to *Mastodon* (*Trilophodon*) *tapiroides*. In the collection of the Rev. H. Canham.

Fig. 5. *Conus*, sp. A gutta-percha pressing from a concave cast in one of the Suffolk Box-stones. The nodule is in the collection of the Rev. H. Canham; the pressing is in the Society's cabinet.

Fig. 6. *Voluta auris-leporis*. A natural cast in Diestien sandstone from the Suffolk Bone-bed. In the collection of the Rev. H. Canham.

Fig. 7. A large and flat *Venus*, from a gutta-percha pressing taken from a concave cast, in a Suffolk Box-stone. The nodule is in the Rev. H. Canham's collection; the pressing is placed in the Society's cabinet.

Fig. 8. Natural cast of the interior of a small species of *Cassidaria*, occurring in a Suffolk Box-stone. In Mr. Canham's collection.

Fig. 9. Gutta-percha pressing from the concave cast of a similar shell, showing the form of the apex of the shell and its surface-markings. In a Box-stone belonging to the Rev. H. Canham.

Fig. 10. *Isocardia lunulata*. An abundant form in the Belgian Black Crag, not uncommon in the Suffolk Box-stones. Gutta-percha pressing from a nodule belonging to the Rev. H. Canham.

Discussion.

Mr. Boyd Dawkins had arrived at a different conclusion from the author, though the discoveries recorded in works on palæontology showed a marked difference between the Suffolk and Norfolk Crag-faunas, such as was not borne out by an examination of collections. He considered that the forms of Ruminants showed a contemporaneity between them. The supposed *Cervus dicranoceros* of Owen was, in fact, another form of deer, which was common to the base of both the Suffolk and Norfolk crags. The *Elephas meridionalis* and *Mastodon arvernensis* had been found side by side in Norfolk, at Montpellier, and in the Val d'Arno, and were therefore probably contemporary. The different lithological character in the two counties was probably due to the different nature of the underlying beds—London Clay and Chalk.

Sir Charles Lyell was much struck with the perfect identity between the box-stones of Suffolk and some exceptional Antwerp beds which he had seen at Berchem, and considered that this was sufficient to prove they belonged to the same deposit. He thought that the area between Belgium and England might have contained a large number of terrestrial beds which eventually left a certain number of their contents to be mingled together in the lower beds of the later marine deposits.

The Rev. J. Gunn produced from the Red Crag at Waldringfield

a portion of the tooth of *Elephas meridionalis*. He insisted on the complex nature of the forest-beds, which consisted of two parts, the lower, estuarine, containing *E. meridionalis* and extinct forms of deer, and the upper, terrestrial, with remains of *E. antiquus* and much altered forms of *E. meridionalis*, approaching in some respects to *E. primigenius*.

Prof. Ramsay pointed out the necessity of there being a great intermixture of remains of various characters and ages in such deposits as the Crag. If, for instance, Auvergne, which had not been submerged since Eocene times, were now depressed below the sea, future geologists might find the remains of Miocene animals intermingled with those of the present day.

Mr. Ray Lankester, in reply, contended that the Miocene forms of *Hipparion*, *Rhinoceros Schleiermacheri*, the trilophodont Mastodon, and other Miocene animals had never been found in the Norfolk beds; while *Elephas meridionalis* had not been found in those of Suffolk. His hypothesis accounted for the facts mentioned by Mr. Dawkins, whilst Mr. Dawkins's hypothesis did not account for the facts adduced in the paper. The specimen brought by Mr. Gunn was decidedly not from the Suffolk Bone-bed, but from overlying beds.

---

2. *Notes on an* Ancient Boulder-clay *of* Natal. By Dr. Sutherland, Surveyor-General of the Colony. Contributed on Dr. Sutherland's behalf by Dr. Mann, F.R.G.S., F.R.A.S.

[Communicated by Prof. Ramsay, F.R.S., F.G.S.]

There is largely developed in the Colony of Natal a formation which seems to be in all essential particulars identical with Mr. Bain's claystone porphyry of the Cape of Good Hope. This formation flanks a long range of sandstone hills, which runs from the Tugela river frontier, at a distance of some six or eight miles from the sea, across the Umgeni river, and through the Berea hills to the mouth of the Umbilo. It also crops out extensively near Maritzburg, and stretches thence, in one direction, over the Umgeni and Umvoti to the Tugela valley between Greytown and the Biggersberg; and in the other direction over the Umlasi and Umkomasi towards the opposite frontier. In the latter course it goes onwards to the St. John's river and to the further districts of the Cape.

The deposit itself consists of a greyish-blue argillaceous matrix, containing fragments of granite, gneiss, graphite, quartzite, greenstone, and clay-slate. These imbedded fragments are of various size, from the minute dimensions of sand-grains, up to vast blocks measuring 6 feet across, and weighing from 5 to 10 tons. They are smoothed, as if they had been subject to a certain amount of attrition in a muddy sediment; but they are not rounded like boulders that have been subjected to sea-breakers. The fracture of the rock is not conchoidal, and there is manifest in its substance a rude disposition towards wavy stratification. The general appearance is

that of a clay which has been deposited by aqueous action, and afterwards metamorphosed by heat, pressure, and chemical action. In places the deposit exhibits the most unmistakable ripple-markings, which seem to indicate that the wind, or other force, which agitated the water during the period of deposit, acted at different times in different directions. The thickness of the deposit varies in different situations, but in some places amounts to as much as 1200 feet.

The clay is compact and tenacious, and unfavourable to abundant supply of water. Borings into its substance remain dry to almost any depth. The surface-soil, which is associated with the formation, is stiff and non-fertile until it has been loosened to a considerable depth and thoroughly worked.

The boulder-bearing clay rests generally upon old Silurian sandstones, which in their turn are based upon granite and gneiss, and which in that connexion constitute the peculiar South-African table mountains. Upwards it passes first into newer shales, and through them into the sandstones and shales, which are associated in Natal with Carboniferous deposits. The transition is very gradual, without any distinct line of demarcation, and often stretches through a quarter of a mile of debatable ground. The transition is very well seen in the Town hill directly above Maritzburg. The only real difference between the shale and Boulder-clay seems to be, that in one of them the matrix is of uniform homogeneity and fineness, while in the other extraneous fragments of rock are brecciated in the argillaceous substance. Near the Umpambinyone and Umzinto rivers the boulder-bearing clay passes into beds which very nearly simulate the condition of true slate, but have their lines of cleavage in the direction of, instead of transverse to, the general stratification. In one instance, in this situation, there is a fine flagstone very closely resembling the Caithness Sandstone. Ripple-markings are plentifully developed where the Boulder-clay passes into these fine slates and flagstones.

The old sandstones which lie immediately beneath the Boulder-clay have their upper surface, in many instances, deeply grooved and striated, as if a semiplastic substance, containing hard and angular fragments, had been passed over it with considerable pressure.

The rocky fragments imbedded in the Boulder-clay formation are all of them of the character of the rocks that are contemporaneous with, or inferior to, the Silurian Sandstone. Fragments of a higher series are never found in the matrix. In some instances very ponderous rock-fragments are found as much as fifty or sixty miles away from the sources of their derivation.

Mr. Bain, in his communication to the 'Journal of the Geological Society' in the year 1856, has very exactly expressed the condition and relations in which this boulder-formation is found in Natal, flanking the sandstone-beds which cap the granite and gneiss. It is, however, certainly very questionable whether this so-called Claystone Porphyry of Mr. Bain is really of the nature of porphyry.

Dr. Sutherland holds that it is obviously a brecciated conglomerate, derived from aqueous deposit, rather than an igneous porphyry, and he urges the following reasons in justification of this view.

In the first place, he has sought for years for the vent through which such a vast mass of erupted rock could have been thrown. Where such a mighty mass is concerned its eruption from beneath could not have been effected without leaving very obvious marks of volcanic disturbance. There are no such indications anywhere. Mr. Bain has suggested the possibility of some such vent having existence about the sources of the Orange river. In that district there is certainly no trace of such rock-convulsion.

Then the abundant ripple-markings, and the gradual transition into fine shales and sandstones of unquestionably aqueous origin, are incompatible with the theory of volcanic or igneous formation; as is also the rubbed condition of the fragments, and the absence in them of all signs of fire-action or fusion.

And yet, again, there is the transport of the vast ponderous blocks to long distances, and the scorings and groovings of the sandstone upon which the Boulder-clay formation rests, to be accounted for.

On the whole, these circumstances seem to indicate that the constituents of this Boulder-clay have been derived from the superficial denudation of older rocks by aqueous agency, and that it has assumed its existing relations to the other rocks while in the condition of a moist and plastic mass. In all probability the finer shales, containing impress of the ripple-marks, were formed during periods of approximate repose; and cataclysmic violence and disturbance had ceased altogether when the deposit of such beds as the Maritzburg shales began.

Dr. Sutherland inclines to think that the transport of vast massive blocks of several tons' weight, the scoring of the subjacent surfaces of sandstone, and the simultaneous deposition of minute sand-grains and large boulders in the same matrix, all point to one agency as the only one which can be rationally admitted to account satisfactorily for the presence of this remarkable formation in the situations in which it is found. He believes that the boulder-bearing clay of Natal is of analogous nature to the great Scandinavian drift, to which it is certainly intimately allied in intrinsic mineralogical character; that it is virtually a vast moraine of olden time; and that ice, in some form or other, has had to do with its formation, at least so far as the deposition of the imbedded fragments in the amorphous matrix are concerned. He dwells particularly upon the fact that Prof. Ramsay has already assigned certain breccias of Permian age to glacial periods and agency, and that there is good reason for referring the coal-bearing shale of Natal, into which this boulder-bearing clay passes almost imperceptibly, to the Permian system.

For these various reasons, Dr. Sutherland submits that the Boulder-clay formation of Natal should be classed with the Permian glacial breccias of Prof. Ramsay.

Discussion.

Dr. Mann called attention to some specimens which he had brought in illustration of Dr. Sutherland's paper, showing the gradual transition from a state closely resembling that of an igneous rock, into that of a truly stratified deposit.

Mr. T. M'K. Hughes, while admitting a recurrence of glacial periods, disputed the evidence in the cases hitherto brought forward. He adduced instances of similar accumulation of similar fragments in recent and ancient deposits which could not be referred to glacial origin; and showed how striation of the included fragments was frequently produced by movements in the mass subsequent to consolidation, pointing out that the supposed glacial deposits of Old Red age were formed under conditions similar to those under which such irregular accumulations were formed at the present day; that all the striated fragments occurred close to faults; that the Permian in the north of England, where it was deposited between high mountains, and might therefore be expected to be supplied in part by glaciers, contained no fragments from the higher ground of the Pennine range. He urged that the Natal deposit was not like a Boulder-clay, being ripple-marked and distinctly bedded, and that it had been subjected to pressure so great as to have produced distinct cleavage.

Prof. Ramsay combated the views of Mr. Hughes, and maintained that there was no necessity for supposing that all the pre-Carboniferous rocks were above water at the time of the deposit of the Permian beds of the north of England. Still he had never maintained that any of those deposits were due to glacial action, but only more southern beds. He pointed out that in the Natal beds under discussion enormous blocks of rock occurred, which were 60 or 80 miles from their original home, and still remained angular; and there was a difficulty in accounting for the phenomena on any other hypothesis than that suggested. He still maintained the probability of the occurrence of glacial episodes, not only in Permian but in other ages, as he had done now fifteen years ago. A Boulder-clay might be recognized, not only by the striæ on the stones, which were not always present, but by their shape and the general character of the agglomeration of the beds.

---

3. *On the Distribution of* Wastdale-Crag Blocks, "Shap-Fell Granite Boulders," *in* Westmoreland. By Professor Robert Harkness, F.R.S., F.G.S.

[Plate XXXV.]

The dispersion of blocks of porphyritic granite, which have been originally derived from Wastdale Crag, a hill lying three miles south of Shap, in Westmoreland, has long excited the attention of geologists. These granite blocks, to which the term "Shap-granite" boulders has been applied, are alluded to as early as 1836

by Professor Phillips, who has described the direction which these blocks have taken during the period of their dispersion; who also mentions the occurrence of these blocks on Stainmoor, a pass in the Pennine chain, and their having travelled over some of the hills and valleys of Westmoreland, South Durham, and Yorkshire*.

Wastdale Crag, from which these blocks have been derived, is a low rounded hill, a little more than four miles N.W. of Tebay station, on the Lancaster and Carlisle railway. It is composed wholly of porphyritic granite, which, on the western side of the granitic area, attains an elevation of about 1600 feet above the level of the sea.

This area of porphyritic granite is flanked, on the western side, by ashes and porphyries, which belong to the Bala age; and these ashes and porphyries on this side, immediately adjoining the granite, attain to a greater elevation than the granite, rising to a height of 1853 feet in the summit of Wastdale Pike; and a little further westward some of the hill-tops are somewhat higher.

The granitic area of Wastdale Crag has a somewhat irregular outline. Its greatest breadth is from E.S.E. to W.N.W., being about two miles across. In a north and south direction, the greatest length which it attains is about $1\frac{2}{5}$ mile†.

The country for about $1\frac{1}{4}$ mile east of Wastdale Crag is somewhat open and flat, with an elevation of about 1100 feet above the sea.

A short distance further east it sinks down to about 800 feet, so that the highest point of the granite is about 800 feet above the country immediately east of the Crag.

The district east of Wastdale Crag is the area over which the great mass of the granite blocks has been dispersed; but this dispersion is not confined to an eastern course. Large blocks of granite are very abundant in the town of Shap, and they can also be seen in the walls for a distance of about half a mile west of Shap, on the road to Shap Abbey‡. Their position here is about three miles due north of Wastdale Crag, and the blocks, as contrasted with such as are seen in Shap itself, are of a comparatively small size. There are, however, some large blocks of rocks in the fields between Shap and Shap Abbey, which have received the name of "Thunder-stones." These are not granite masses, but consist of green porphyries, which have come from the high ground on the west side of the river Lowther.

The country which lies east and north-east of Shap exhibits great quantities of Wastdale-Crag boulders. In a N.N.E. direction, they can be traced six miles from Shap, being seen in the walls and

* Geol. of Yorkshire, vol. ii. p. 162.

† I am indebted to the kindness of W. T. Aveline, Esq., of the Geol. Survey, for furnishing me with a tracing of the granite area of Wastdale Crag.

‡ In many localities where Wastdale-Crag blocks and other large boulders occur, they have been removed from their original positions in consequence of agricultural improvements. They have been used extensively for walling-purposes, and, in many spots, large blocks of these rocks have been made use of for basement courses of houses and farm-buildings.

farm-buildings in the village of Cliburn. They do not, however, seem to occur in the country which lies west of a line from Shap to Cliburn.

They can be recognized about two miles N.E. of Cliburn, at Temple Sowerby. I learn from Professor Phillips that he has seen Wastdale-Crag blocks at Long Wathby, on the east side of the river Eden, at a distance of $5\frac{1}{2}$ miles north from Cliburn; and this is the most northern limit which has been yet recognized of the occurrence of these blocks. Long Wathby is four miles N.E. of Penrith. In the interval between those two places no Wastdale-Crag blocks have been found, nor are there any traces of them in the district between Penrith and Cliburn; and in the country due S. and S.W. of Penrith their occurrence is unknown.

From the south side of Wastdale Crag, the granite blocks have taken a S.E. course.

They are found as far south as Tebay; and I learn from Mr. M'K. Hughes that, although few of them cross the river Lune, he has met with them at a distance of about one-third of a mile south of the village of Langdale, which is about half a mile south of the Lune. From this spot the direction of their course has an E.S.E. boundary, which leads into the valley of the Eden. In the upper portion of this valley, they are not seen so far south as Kirkby Stephen, but about $2\frac{1}{2}$ miles to the N.N.E. thereof, at Brough Sowerby, they occur in considerable abundance. They do not, however, seem to make their appearance on the south side of the River Bela, a stream which runs into the Eden between Kirkby Stephen and Brough Sowerby. From the Bela the boundary of their southern distribution runs E.N.E. to Stainmoor, and very few make their appearance on the south side of Argill beck, and none seem to occur along the line of the South Durham railway between Kirkby Stephen and the summit-level. They can be seen on the north side of Argill beck, a very fine block occurring near a small public-house, about half a mile N.W. from the farm called Palliard.

Few, if any, of the blocks of Wastdale-Crag granite appear to have crossed the watershed which separates the Argill on the west from the Greta, a tributary to the Tees, on the east. This watershed, at its lowest part, namely, the summit-level of the South Durham railway, is 1378 feet above the sea.

A small stream, called Augill beck, drains the northern side of Stainmoor, and a watershed, about 1490 feet high, separates this stream from the source of the Black beck, a rivulet which flows into Balder beck, a stream draining the moory country on the east side of the Pennine chain, known as Hunderthwaite Moor. Between the sources of the Augill and the Argill becks, Stainmoor rises to a height of more than 1500 feet above the sea-level; and this high ground, which has a N.W. and S.E. extension for about four miles, forms the eastern boundary of the area of distribution between these two streams.

There is abundant evidence, when we get north of this high portion of Stainmoor, that Wastdale-Crag granite blocks have found

their way over the watershed between Augill beck and Black beck, and that over this watershed, at a height of about 1490 feet, the great bulk of the boulders which occur in the country east of the Pennine chain have passed.

A block of this granite can be seen on the eastern side of this watershed, a short distance to the S.E. of Harton Crag, which is near the summit of the ridge; and Prof. Phillips mentions the occurrence of these blocks on the summit of an isolated hill called Goldsborough, which lies about 6½ miles east of this watershed*. They are also to be met at lower levels in the valley of the Balder. But Wastdale-Crag granite blocks are by no means so abundant here as are boulders of porphyry, which have also come from the eastern sides of the Westmoreland portion of the Lake-district mountains.

A parallel valley runs eastwards at the distance of about 2½ miles south of Balderdale. In this valley, called Deepdale, Wastdale-Crag granite blocks, associated with porphyries, also occur. Some of the former, which are of a large size, are seen in the lower part of this vale, in the neighbourhood of Lartington.

Reverting again to the eastern limits of the dispersion of Wastdale-Crag blocks in Westmoreland, we have the steep front of the Pennine chain forming this boundary north of the watershed above alluded to. In Westmoreland, this chain has nearly a N.W. course.

Blocks of granite are, however, by no means abundant on its sides, but they have been recognized by Dr. H. A. Nicholson and myself at a height of about 700 feet above the level of the sea, in the course of Pusgill beck, at a short distance to the N.E. of the village of Dufton.

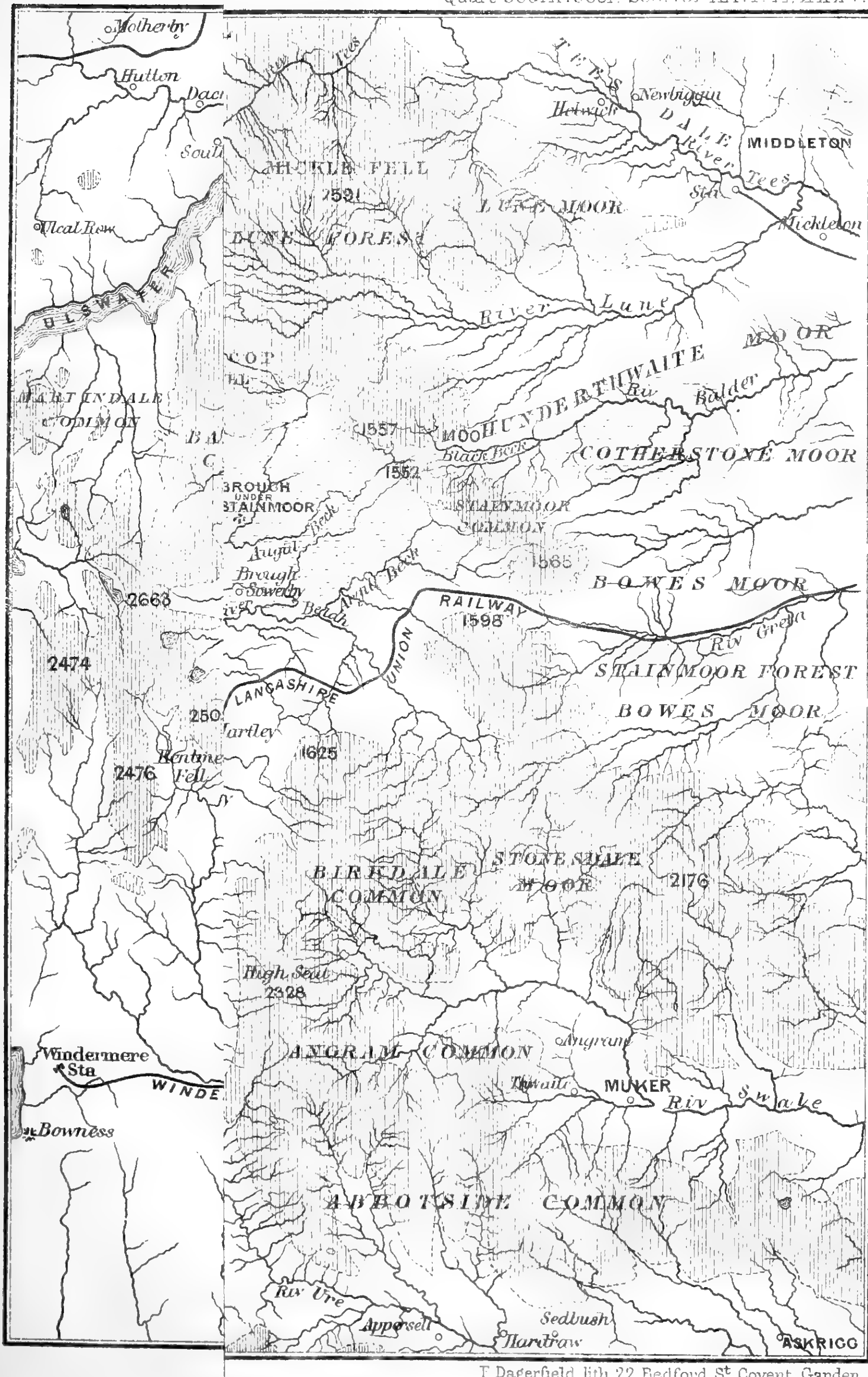
The area in Westmoreland over which Wastdale-Crag blocks have been distributed, although irregular in its outline, has somewhat of a triangular form. Its greatest breadth is in an E.N.E. direction, namely, from Wastdale Crag to the watershed separating Augill beck and Black beck; and this distance amounts to 19 miles. In a north and south direction the greatest recognized length of distribution is from Long Wathby to a little south of the village of Langdale, near Tebay, which is 18 miles.

In the area of distribution of the Wastdale-Crag blocks there is a wide difference in the abundance in which those blocks occur.

Near the western margin of the area they are found in great plenty within about three miles from their parent sources. Beyond this they become less abundant, and near the northern limit of the area they are very rare. Near the eastern boundary, which is at a considerable distance from the parent mass, they are by no means common, except near the line of their route across the Pennine chain.

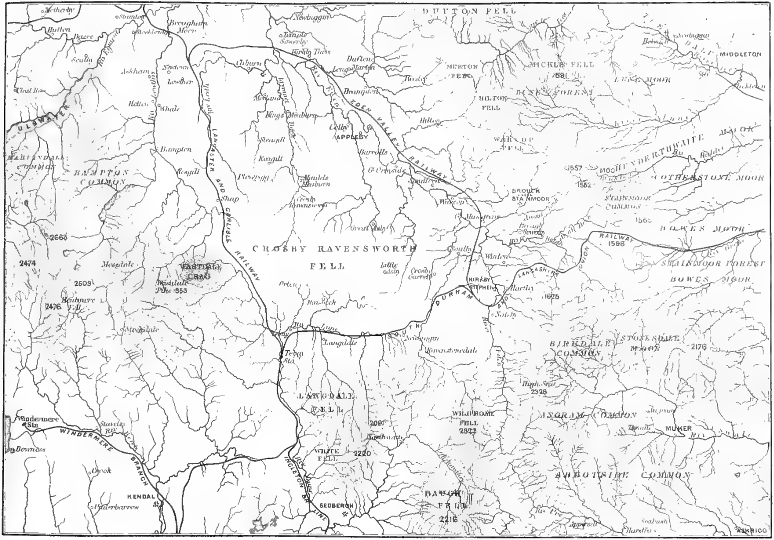
With reference to the more central portions of the area of distribution in Westmoreland, there are also great differences in various localities in the quantities of their granite blocks. Two valleys

* *Op. cit. suprà.* Professor Phillips applies this name to a hill different from that which bears it on the map of the Ordnance Survey.



T Dagerfield lith 22 Bedford St Covent Garden

ALE CRAG.



MAP OF THE VICINITY OF WASTDALE CRAG.

intersect the area of distribution, one of which, that of the Lyvennet, is comparatively small, and runs nearly from south to north to beyond Cliburn, where it joins the Eden; the other is a wide vale, having little high ground on its west side, but on the east it is margined by the Pennine chain. The course of the Eden in Westmoreland is from S.E. to N.W.

In the areas drained by the Lyvennet and the Eden, the occurrence of Wastdale-Crag boulders varies according to locality. The Lyvennet has its origin in Crosby Ravensworth Fell, at a spot a little more than a mile N.W. of the town of Orton. Here granite blocks are abundant, and they are also common in the neighbourhood of Orton, but not to the same extent as on Crosby Ravensworth Fell, and south of Orton they are comparatively rare. North of Crosby Fell they become very common, being seen in great quantities near the villages of Crosby Ravensworth and Maulds Meaburn, on the Lyvennet. They are also common about the village of Reagill, but not so abundant as to the south thereof. Between the portion of the country just alluded to and the western margin of their distribution, they occur in enormous profusion, and it is in this district that they are found in the greatest abundance. Following the valley of the Lyvennet northward, we find them comparatively rare north of Reagill. They are, however, to be met with between that place and Morland, a village about three miles further north, and also in the country to the east thereof. North of Morland they are rarely seen, but, as before stated, they can be recognized in the walls of the farm-buildings at Cliburn, $1\frac{1}{2}$ mile still further northward.

In the valley of the Eden, which is further removed from their original source than the Lyvennet, they are not so profuse in their occurrence. It has already been stated that they are unknown in this valley as far south as Kirkby Stephen; and it is immediately north of the river Bela where they are first recognized. The buildings at Brough Sowerby furnish them in considerable quantities, and some are here also to be seen on the surface. A few occur near Brough itself, and they are abundant near the village of Great Musgrave. The neighbourhood of Warcop exhibits them in considerable profusion, but north of this they begin to become rare; they can, however, be found in the country round Appleby, and are occasionally seen in the walls.

From Appleby northwards their occurrence is uncommon. There are, however, a few spots near Kirkby Thorpe and Temple Sowerby which afford them; and, as before mentioned, Professor Phillips has recognized them as far north as Long Wathby.

In the valley of the Eden, the area of their greatest distribution has a W.S.W. and E.N.E. course, and passes between Great Musgrave and Warcop. This area, if extended westwards into the valley of the Lyvennet, and from thence to the parent source of these blocks, would give us the region of their greatest distribution, between the valley of the Eden and Wastdale Crag. If we extend this area eastwards from the valley of the Eden, it would mark the

course which the blocks have taken in their passage over the high ground of Stainmoor.

The area over which the granite blocks of Wastdale Crag have been dispersed is indicated in the map (Pl. XXXV.) by the portion marked with broken lines.

With reference to the relation which the blocks of Wastdale-Crag granite bear to the Boulder-clays of Westmoreland, it would seem, from the position of the former, that they have been dispersed after the deposition of the latter. The granite blocks occur in great profusion *on the surface* in the country between Wastdale Crag and the valley of the Eden. They do not make their appearance in the Boulder-clay. They are, however, occasionally met with in a clay which overlies the boulder-deposits; but in this clay none of the characteristic scratched blocks of the Boulder-clay proper are found. This clay, overlying the Boulder-clay, is of local occurrence. It is seen at Gaythorn tile-works in Gaythorn plain, about five miles E.N.E. of Wastdale Crag. Here it has its origin from some shale-beds which occur in the carboniferous formation at this spot, and it is seen resting upon well-marked Boulder-clay.

In the vale of the Eden the Boulder-clay is largely developed, and good sections of it are exhibited in the cuttings of the Eden-valley branch of the South Durham railway. In no instance do any of these sections afford traces of blocks of Wastdale-Crag granite; and although boulders abound in this clay, they have been, for the most part, derived from the Carboniferous formation. Occasional porphyritic blocks, such as might have been derived from the lake-country, and fragments of Coniston flags, which may have come from the Ravenstonedale district, are also seen in the Boulder-clays of the valley of the Eden.

Near the N.W. portion of the area of distribution of the Wastdale-Crag blocks, fragments of these become very rare; but masses of Lower Silurian porphyries and slates are common on the surface. Masses of granite also make their appearance; but this granite has a very different aspect from that of Wastdale Crag, and these blocks seem to have come from Criffel, a granite hill on the S.E. side of the Stewartry of Kirkcudbright. As we proceed north from the area of the distribution of the Wastdale-Crag granite, the blocks from Criffel become more abundant. This Criffel granite occurs, not only in the form of blocks on the surface, but is found also in the Boulder-clays. It can be seen in this position at Brougham brick-works, about two miles W.N.W. of Cliburn, which is somewhat beyond the limits of the distribution of the Wastdale-Crag blocks. The Criffel granite blocks are also common in the Boulder-clays of the vale of the Eden, in Cumberland. They are likewise found in great abundance among the Eskar mounds near the road between Penrith and Long Wathby; and here they have been derived from the Boulder-clay upon which these Eskar drifts repose.

Judging from the mode of occurrence of the Criffel granite blocks, as compared with those of Wastdale Crag, it would appear that the former had, to a large extent, been distributed before the latter;

but, as both occur on the surface, the distribution of the former must also have been continued during that of the latter.

The moory ground which lies immediately east of Wastdale Crag has its surface marked by several mounds of sand and gravel. These have all the aspects of Eskars; and they contain rounded fragments of Wastdale-Crag granite. These mounds may, however, have been formed at a more recent date than those Eskars which, in the valley of the Eden, yield blocks of Criffel granite.

With respect to the surfaces of the rocks upon which the Boulder-clay rests, these surfaces in many instances exhibit glacial scratchings. One of the localities which afford these scratchings is at a short distance east of Gaythorn Tile-works. Here, in a small quarry, the surface of the Carboniferous limestone is beautifully marked with striæ, which have a nearly north and south course.

These striated rocks, which were seen by Sir Charles Lyell, Mr. M'K. Hughes, Dr. H. A. Nicholson, and myself, seem to have been first noticed by Mr. Lightfoot, who was formerly on the Geological Survey, and who was for a while engaged in this portion of Westmoreland. The striated surface of the limestone here has a thin bed of Boulder-clay resting upon it. The direction of the striæ follows the course of the valley, and is almost at right angles to the line taken by the Wastdale-Crag granite blocks, which overlie the Boulder-clay in this neighbourhood.

Glacial striæ may be seen in several localities in Westmoreland; and wherever they occur their direction corresponds to the course of the valleys. This is the case not only with the vales of the Lyvennet and the Eden, but also with those small dells which contain the tributaries to these streams. The same circumstance is seen likewise in the valley of the Lowther, a river which has its origin, in part, from Wastdale Crag, and which, after flowing northwards, joins the river Eamont about a mile south of Penrith. These striæ, formed by ancient glaciers, and running in the direction of the present valleys, indicate that the drainage of the country and its present outline have not been much altered since the operation of glacial action; and they strongly support the inference that the outline of this portion of Westmoreland approached pretty nearly to what it is now during the time when the Wastdale-Crag blocks were being distributed.

On referring to the hill-shaded inch-to-the-mile Ordnance-map of the district where the granite blocks occur in the greatest abundance, it will be seen that this portion of Westmoreland is occupied by numerous small valleys having a north and south direction, a course corresponding to that of the striæ which these valleys afford. Many of these small valleys have steep escarpments facing towards the west or towards the granitic area of Wastdale Crag. The valley of the Lyvennet also exhibits the same features. It is in this direction that the limestones and other rocks of the Carboniferous formation have their outcrop. On the east side of the vale of the Eden, the same circumstance manifests itself in the bold western outcrop of the rocks which form the Pennine chain; and even

on the lower portion of this chain, on Stainmoor, over which the Wastdale-Crag blocks have travelled, escarpments of Carboniferous rocks facing westwards are common. Speaking generally of a section from Wastdale Crag to Hunderthwaite Moor, on the east side of the Pennine chain, showing the contour of the surface, it may be said that the escarpments face towards the west, and that the gentler slopes incline towards the east.

The mode by which the granite blocks of Wastdale Crag have been transported over the hilly portion of Westmoreland and from thence across the Pennine chain has excited the inquiry of geologists, but as yet no satisfactory conclusions have been arrived at concerning the process which effected this transport.

Among other causes glaciers have been regarded as the agents. There are, however, some circumstances which render this mode of transport very improbable.

It has already been shown that the valleys of the Lyvennet and the Eden, and their smaller dells, are of an age considerably anterior to the period of the dispersion of the Wastdale-Crag blocks; and also that the outline of the surface of the country over which these blocks have passed has undergone comparatively little change since the time when glaciers furrowed the surfaces of the rocks upon which the Boulder-clays repose. These ancient glaciers have followed the courses of the present drainage of the country, or, in other words, have had a motion from south to north so far as the valleys of the Lyvennet and the Eden and their subordinate vales are concerned. A glacier of considerable size must have occupied the valley of the Eden, which was fed by tributary glaciers, especially from the west side of the Pennine chain; and a smaller glacier, with still smaller feeders, must have had its course along the valley of the Lyvennet.

The country immediately east of Wastdale Crag is of such an outline as to furnish none of the conditions necessary for the formation of glaciers; but on the north and south side of this hill the surface-outlines are in every way such as would give rise to such products.

On the south side there is a valley the head of which is Great Yarlside, attaining an elevation of nearly 2000 feet above the level of the sea. This valley is flanked at its N.E. termination by the granite of Wastdale Crag, which in some spots affords glacial scratches, the direction of which corresponds to the course of the valley, which, after running for about a mile N.E. of Wastdale Crag to Shap Wells, turns to the S.E., and flowing for about four miles in this direction, under the name of the Birkbeck, joins the Lune at Tebay. The direction of this stream is the course which a glacier would have taken had it occupied this valley and the country in front of it during the period when the granite blocks were being distributed.

On the N.W. side of Wastdale Crag is a valley known as Wet Sleddale; this is drained by the sources of the river Lowther, which originate in the high ground on the north side of Great Yarlside. A glacier occupying this valley during the rigorous climate of the glacial epoch, would have extended itself towards the N.E.

for about three miles; after which, had the area been land, it would have accommodated itself to what is now the valley of the Lowther, and assumed a northerly direction.

Independently of the direction of these old valleys, which must have influenced the courses of the glaciers, the outline of the country, with its slopes between Wastdale Crag and that portion of the Pennine chain which has been crossed by the granite blocks, is altogether hostile to the idea of a glacier having been the transporting agent of these masses of granite. The prominent escarpments fronting this glacier would have diverted it from an eastern course; otherwise these escarpments would have been planed down by its action, and all traces of the north and south striæ which now mark the faces of the rocks would have been obliterated, and their places occupied by others of a more recent date, running from west to east; yet no such markings are to be found. The idea, therefore, which suggests a glacier as the agent of the transport of these blocks has very little to support it.

Another cause has been looked upon as the transplanting agent of the Wastdale-Crag blocks, namely, icebergs; and this certainly is a much more probable means of dispersion than the action of glaciers. There are, however, some difficulties attendant on the iceberg theory, which seem to render it by no means easy of acceptation. If we assume glaciers to have occupied valleys on the north and south sides of Wastdale Crag (and of this there is very little reason to doubt), and if we are to attribute icebergs to such glaciers, the greatest portion of the mass of Wastdale Crag, which has furnished the blocks, would have been under the surface of the water on which those icebergs floated. By far the largest portion of Wastdale Crag is at a lower level than 1500 feet above the sea; in fact very little of the hill, except its western side, attains an elevation equal to that portion of Stainmoor over which the blocks have passed in their route to the valley of the Tees. Assuming icebergs to have been the agents of transport, it would have required the sea to have been at least 1500 feet above its present level, otherwise there would not have been a sufficient depth of water to have enabled blocks to have floated over Stainmoor into the valley of the Balder.

[In the accompanying map (Pl. XXXV.), the outline which the land would assume if the sea were 1500 feet above its present level is shown by the portion marked with perpendicular lines. The whole of the area left blank, and also that marked with broken lines, would, under such circumstances, be under water].

If it be assumed that the granite of Wastdale Crag rose to a higher level than it does at the present time, during the period of the distribution of the granite blocks, still that higher level would hardly suffice to furnish materials to a glacier, portions of which would be detached and float away as icebergs.

There is another difficulty with reference to the iceberg theory of transport. This is the size of the bergs themselves. If we suppose these to have had an average of 50 feet in height above the surface

of the water, this would presume a mass eight times this size below the surface; and assuming this comparatively small size for those bergs, we should have them extending to the depth of 400 feet beneath the water. The floating of such a mass of ice is altogether incompatible with the idea that these blocks were carried over Stainmoor, when the sea was about 1500 feet higher than at present.

If we assume a greater height of sea-level, and one sufficient to float such icebergs, then we place the whole granitic area of Wastdale Crag considerably below the water-level, and in such a position as to render it unavailable to furnish materials for transport.

Another objection to the iceberg theory is furnished by the mode of occurrence of the blocks themselves. Their insulated and superficial position is strongly antagonistic to this idea. If we suppose icebergs, bearing mineral matter, to have been stranded in the areas where the Wastdale-Crag blocks are found, the melting of these, either wholly or partially, would have left some of the earthy mud and sand so abundant among ice-transported materials; and in such mud and sand the blocks would have been seen. Nothing of this kind, however, occurs; for the blocks alone seem to have been the materials transported.

There yet remains to be considered another agent which could have transported the blocks of Wastdale Crag: this is coast-ice; and this agent seems less liable to objection than either the action of glaciers or the operation of icebergs.

Such an agent is now in action in high latitudes; and the effects which result therefrom, both in Europe and America, have been well described by Sir Charles Lyell *.

If we suppose the sea-level, at the period of the transportation of the Wastdale-Crag granite blocks, to have been at the height previously assumed, namely, 1500 feet higher than at present, although a large portion of the granite area, as it is now seen, would have been beneath the sea-surface, there would still remain sufficient above and near the surface to have afforded blocks.

These blocks, when frozen in ice-sheets, would be in a position easily capable of transport, when the sheets became broken up. Blocks imbedded in and lying upon such ice-rafts would require no great depth of water for their transport.

These ice-rafts would be dependent upon winds and currents for their direction: their course west was impossible, as the land lay on that side. There remained, however, a north, south, and east course for them to take.

With reference to the former, the northern course, there is evidence which supports the inference that in this direction their motion would be materially interfered with by currents setting in from the north-west and north. The evidence of the existence of such currents during the period of the transportation of the Wastdale-Crag blocks, is indicated by the occurrence of blocks of Criffel

* Principles of Geology, 10th ed. vol. i. p. 383.

granite over the Cumberland plain and in the valley of the Eden. The southern current is not so clearly indicated; still the absence of Wastdale-Crag blocks from the valley of the Lune to the south of Wastdale Crag supports, to some extent, the supposition of its existence*.

The combined influence of a northern and a southern current with land to the westward would give rise to a current having nearly an eastern course; and a current having such a direction would carry ice-sheets loaded with blocks over Stainmoor.

The existence of water at or near such a high level, at or immediately after the period of the transportation of Wastdale-Crag blocks, is shown by the occurrence of Eskars, which have been already alluded to as making their appearance near the east base of Wastdale Crag.

These are seen in some spots at a height of about 1100 feet above the present sea-level; they exhibit a great amount of false-bedding, and they are seen scattered over a moor in positions where no river-action could have operated to produce them.

Professor Phillips, in a communication to the British Association (Report, 1864), expresses an opinion that the distribution of the Wastdale-Crag blocks "cannot have been performed by ice-flotation in an ocean, however elevated, if the present relative elevations of the country were the same as now." Judging from the age of the valleys in Westmoreland it would, however, appear that this relative change of level, if it has taken place at all, could not have been of such a character as to give rise to the present general outline of the country. Some slight relative changes may have taken place on one side or other of the great Permian fault, but no such change as could have materially affected the general contour of the district east of Wastdale Crag.

Even had such changes of level taken place on opposite sides of the Pennine fault, there would still be the difficulties which arise when we consider the surface-outline of Westmoreland, over which the blocks have travelled, to be overcome.

Reference has been made to the Boulder-clay of Westmoreland; and in this Boulder-clay it has been shown that no Wastdale-Crag blocks occur. As the Pleistocene formation, in some parts of England and Ireland, exhibits three well-marked periods,—namely, first and lowest, Boulder-clays, resting on sands and gravels which possess an Arctic fauna; second, gravels, sands, and marls marked by a fauna of a less Arctic character; and third, another Boulder-clay which, in the valley of the Clyde and elsewhere, is capped by beds containing shells also of Arctic types,—the inquiry naturally occurs, To which of these series are we to assign the Boulder-clays of Westmoreland upon which Wastdale-Crag blocks are found?

Observations induce the conclusion that of these members of the Pleistocene group the two former, namely, the lower Boulder-clays,

* Blocks of Wastdale-Crag granite are seen on the western side of the Lune, about Selside, six miles due south of Wastdale Crag.

and the middle gravels, sands, and marls, are absent from both Westmoreland and Cumberland, the upper Boulder-clays only being represented. The dispersion of the Wastdale-Crag blocks is therefore of recent occurrence in connexion with the Pleistocene epoch. There are reasons, however, for inferring that this dispersion took place at a period before the Clyde beds were formed, and at a time when, in lower localities, the upper Boulder-clays were still being deposited.

Discussion.

Mr. Hughes pointed out some difficulties in accepting the theory of the transport of these blocks by means of coast-ice, but was not able to offer any better solution of the question than that suggested by the author.

June 8, 1870.

Henry G. Vennor, Esq., of the Geological Survey of Canada, Montreal; Alexander Kendall Mackinnon, Esq., M. Inst. C.E., Director-General of Public Works, Montevideo, South America, and Arthur Roope Hunt, Esq., Quintella, Torquay, were elected Fellows of the Society.

The following communications were read:—

1. *On the* Superficial Deposits *of the* South *of* Hampshire *and the* Isle of Wight. By Thomas Codrington.

[Plates XXXVI. & XXXVII.]

Contents.

I. Introduction.

The district of which it is proposed to treat in the following paper, is comprised betweed Poole and Portsmouth, and extends

inland to Wimborne, Downton, Bramshaw, Romsey, and Bishopstoke; it also includes the Isle of Wight.

Tertiary formations occupy the whole of the area, with the exception of the southern part of the Isle of Wight; and the surface is very generally covered with superficial deposits, which are the immediate subject of this paper.

The rivers Frome, and Trent or Piddle, enter Poole harbour on the west, and the Stour, Avon, Test, Itchen, Hamble, and Titchfield rivers flow through the district. All these rivers, as well as the Medina, Yar, and Brading rivers, in the Isle of Wight, rise in the chalk, or in beds not much below it, and after draining a considerable extent of chalk-country, pass through the Tertiary area to the sea. The Avon water, Boldre, and Exe or Beaulieu river, rise among the Tertiary beds of the New Forest, of which they drain the larger portion.

Among those by whom the superficial deposits of the district have been noticed, are Sir C. Lyell, Messrs. Webster, Prestwich, Trimmer, E. Forbes, Godwin-Austen, Bristow, Evans, &c. Of late years, the discovery of numerous flint implements along the coast between Southampton Water and Gosport, near Bournemouth, and more recently near Southampton, and near Lymington, has given a fresh interest to the gravel from which they are derived; and the publication of the new Ordnance Maps with levels over a large part of the district, has facilitated the construction of many accurate sections of the surface. For the western part of the district, where the new Orduance Survey is unfinished, levels have been supplied me by permission of Sir H. James, from which, and from other sources, as well as from personal observation, the sections have been extended in that direction.

The sections (figs. 1 to 10, Pl. XXXVII.) are selected from many others constructed; they are drawn to a scale of two miles to an inch horizontal, and 800 feet to an inch vertical. The heights in feet above the mean level of the sea are figured at numerous points, and the position of the lines of section are shown upon the map (Pl. XXXVI.).

II. The mainland of Hampshire.

(*a*) The physical features of the country, and its superficial deposits, are so closely connected that they must be considered together. The New Forest, and the neighbouring country between Poole and Southampton Water, is characterized by high level plains, very generally covered with gravel or brick-earth. On closer examination, these plains are found to be portions of a tableland with a very gradual southern slope, through which the larger rivers flow in well-defined valleys, and which has been a good deal cut up and over large areas entirely removed by the action of the tributary streams flowing in what are locally called the "bottoms."

Section No. 1, from Fordingbridge and Breamore to Bramshaw, and No. 2, from Poole to Southampton Water, which are nearly

on the line of strike of the general surface of the country, will illustrate its tabular character and the way in which the rivers intersect it. The extension inland of the tableland is best seen on the east of the Avon, where it can be followed from the coast northwards for upwards of twenty miles to a gravel-capped escarpment, 420 feet above the sea, and 200 feet above the ground immediately to the northward, extending from Downton Common to Bramshaw. It is easy to see that the high plains, such as Picked Plain, Bratley Plain, and Ocknell Plain, although separated by deep valleys or "bottoms," form parts of one continuous tableland, and nowhere is this more evident than near the highest part between Downton, Fordingbridge, and Bramshaw. The eye there ranges over an extensive plateau curiously intersected by valleys 100 to 150 feet deep, by which the tabular appearance of the surface is, however, but little affected.

Section No. 3 commences at the coast near High Cliff, two miles east of the mouth of the Avon, where the cliff is 96 feet high, and is capped with 18 feet of gravel, and extends by two lines branching at Bratley Plain, to the northern escarpment near Bramshaw Telegraph, and at Blackbush Plain, respectively 419 feet and 397 feet above the sea. From the coast to the escarpment the ground has a uniform inclination of about 20 feet per mile, or one-fifth of a degree with the horizon. The surface is generally covered with gravel, which appears to thicken as the ground drops towards the valleys; the sides of the valleys are free from gravel, and the bottoms contain a gravel much mixed with locally derived clay and marl, and distinct from that covering the plains.

The regularity of the surface of the plains, where they are not cut up by streams, is very remarkable, more so on the ground than would perhaps appear from some of the sections, in which the vertical heights being necessarily greatly exaggerated, every irregularity is magnified to about thirteen times its natural scale.

To the westward of the Avon, the triangular tableland between Christchurch, Wimborne, and Poole is cut off on the north by the Stour valley. It varies in height from 100 feet near the coast to 190 feet towards Wimborne, and sections of the gravel covering it are seen along the coast, in the railway-cutting between Christchurch and Bournemouth, in the cutting south of Wimborne, and in numerous gravel-pits. On the north of the Stour at Wimborne, Canon Hill and Cole Hill are capped with gravels at a level corresponding to those of the plains to the south; and still more inland, Chalbury Hill and Pistil Hill are covered with flint-gravel at greater elevations. The latter, a detached flat-topped hill, 320 feet above the sea, corresponds exactly in level with the plain on the opposite side of the Avon, and appears to be the remnant of a sloping tableland, of which the mass has undergone destruction by the action of the Stour, Blackwater, and Avon. Generally the country near the confluence of these rivers is at a much lower level than the high plains, ranging from 30 to 80 feet above the sea, or about 30 feet

above the rivers. Somerley Heath, and Alderholt Heath, although 130 feet above the sea, are still 170 feet lower than the plains on the other side of the Avon, and immediately opposite them.

The bottom of the valley of the Avon is shown by a dotted line on section No. 3. Its fall is at the rate of from 8 feet per mile near Hale to 3 feet per mile near the sea; so that while the tableland near Christchurch is but 83 feet above the valley, at Hale the high plain of Hatchet Green is 300 feet above it.

Bordering on the valley between Fordingbridge and Ringwood, at levels approaching the tableland in height, there are terrace-like plains, which are well seen from the high ground on the opposite or western side of the valley.

On the east of section No. 3 the gravel-covered tableland stretches northward from Barton and Hordwell Cliffs till it is interrupted by the Avon-water valley. The tabular character is carried on by plains at corresponding levels near Wilverley; and beyond an area comparatively low, and drained by numerous tributaries of the Boldre river, is the high ground near Stoney Cross and Castle Malwood, which is continuous with Ocknell Plain, 270 feet above the sea, and gravel-covered. Section No. 4 illustrates the rise of the tableland from the coast to the Avon-water valley and to Wilverley, and shows how a prolongation of the same slope northwards would coincide with the high ground near Stoney Cross.

A section of the gravel covering the tableland is seen in the cliffs between Poole Harbour and the entrance of the Solent. Westward of Poole Harbour there is no gravel on the coast, though a patch occurs at a high level in the valley of the Frome near Rempston House; but between Poole and Bournemouth the cliffs are capped with gravel at from 100 to 120 feet above the sea. It is from this gravel that the flint implements found on each side of Bournemouth are derived. The section in the cliffs is nearly the same as that shown in section No. 2, the general level of the tableland near the coast at Bournemouth being about 120 feet above the sea. Except where it is intersected by the Bournemouth valley or by chines, the gravel-bed is continuous, and from 8 to 15 feet thick, to within about a mile from the mouth of the Avon; there the tableland ends, and a cliff not more than 10 or 20 feet high, is composed of what appear to be the gravel-beds of an old channel of the Avon or Stour, which reach as low as high-water mark. Between them and the present mouth of the river, Hengistbury Head rises to 120 feet, and is capped with the older gravel. About a mile eastward from the mouth of the Avon, the junction of the valley-gravels with the gravel of the plains is seen near Highcliff, and was noticed long ago by Sir Charles Lyell * and by Mr. Godwin-Austen †. From this point to Milford the gravel is again continuous, except where Chuton Bunny and Becton Bunny cut through it. In Barton and Hordwell cliffs the thickness is now as much as from 18 to 20 feet,

* Trans. Geol. Soc. vol. ii. 2nd series, p. 279.

† Quart. Journ. Geol. Soc. vol. xiii. p. 45.

while formerly, it was much more. In 1757* and 1789–1794† the gravel in Hordwell Cliff is described as being from 18 to 20 yards thick; and later, in 1821, Mr. Webster‡ gives the thickness in Barton and Hordwell cliffs as at least 50 feet. As the coast is wasting at the rate of a yard a year, the cliffs which exhibited this thickness of gravel were from 60 to 80 yards in advance of the present coast, and inland the thickness diminishes still more, being only 9 feet in pits about half a mile from the cliffs.

Chuton and Becton Bunnies are cut out in the bottom of higher and broader valleys, on the flanks of which the gravel thins out. The chines in the sandy cliffs to the westward of Bournemouth furnish many sections in which the relations of the older valley and the chine with the gravel covering the plain can be observed. In Allum Chine a bed of gravel and the overlying brick-earth have been cut away by the older valley, on the side of which lies a bed of white gravel, overlapping the edges of the brick-earth and the lower gravel. The chine itself has cut through the white gravel.

Towards the entrance of the Solent the coast-line trends seaward, and the tableland is prolonged to a lower level. Inside Hurst Castle, where the coast is sheltered from the open sea, the gravel plain falls with a gradual slope almost to high-water level (Section No. 5). This is the case all along the shore of the Solent to Eaglehurst, at which point the coast is exposed to the open sea from the direction of Spithead, and has been cut back, and the cliff is consequently higher. At the lower level the country here does not present the same tabular character; from the 100-feet level downwards, the fall appears to be more by steps, and the surface has, moreover, been a good deal modified by the streams.

The plains of Boldre and Beaulieu Heath present the tabular character before described, and rise gradually to an escarpment, which is 140 feet above the sea towards Brockenhurst, and 120 feet near Southampton Water. Northward of the escarpment the general surface of the country is 80 or 100 feet lower, much intersected by the tributary streams of the Beaulieu river, and generally covered by a wash of gravelly loam; but detached gravel-topped hills rise in the lower ground to levels corresponding to the plains, and are evidences of the former extension of the tableland beyond its present northern edge.

The Boldre river, and the Exe or Beaulieu river, flow in well-defined valleys through the tableland, as is shown in section No. 2, which crosses the river-valleys at right angles. In section No. 5, which is nearly parallel to the Boldre river, the bottom of the valley is shown by a dotted line. The fall of the valley is only 4 feet per mile, while that of the tableland adjoining is about 20 feet per mile.

(*b*.) The tableland of Beaulieu Heath abuts boldly upon the western shore of Southampton Water, as section No. 2 shows; but

* Gentleman's Mag. 1757, p. 64.
† Warner's 'Collections for a History of Hants,' vol. i. p. 256.
‡ Trans. Geol. Soc. vol. i. 2nd series, p. 90.

on the opposite or Netley side of the water there is a low gravel-capped cliff, 10 or 20 feet above the sea-level, from which the ground rises at first rather sharply to 60 feet, and then gradually to an escarpment from 200 to 300 feet high, overlooking ground to the north-eastward 140 or 160 feet lower in level (sections Nos. 2 and 6). This escarpment extends from Chilworth, by Bitterne, Bursledon Mill, and Sarisbury Green, to the Titchfield river. It varies in height from 304 feet at Chilworth, to 150 feet near Titchfield, and is roughly parallel to Southampton Water and the coast-line. The surface is very generally covered with gravel or brick-earth, except where it has been removed by fluviatile action; and the rivers Itchen and Hamble and the Titchfield river cut through the tableland exactly as the Boldre and Beaulieu rivers do on their way to the Solent, so that Southampton Water bears the same relation to the former rivers as the Solent does to the latter. The bottom of the Itchen valley is shown in section No. 6 through Southampton to Chilworth and Chandler's Ford. About Shirley, Chilworth, and Toot Hill the carving out of deep valleys in sloping tableland is as remarkable as near Bramshaw telegraph.

The river Test, which is by far the most considerable of the rivers flowing into Southampton Water, is bordered on the west, near Romsey, by high ground covered with gravel, which, near Shootash, attains a height of 275 feet above the sea, or 240 feet above the Test valley. From Shootash a gravel-covered crest runs northwards for two miles, having low ground on the west and a gradual slope towards the river; and high land covered with gravel extends for three miles to the south of Shootash, at an elevation of upwards of 140 feet above the valley.

At Cadbury Farm, one mile north-east of Mottisfont and five miles above Romsey, is a patch of gravel 15 feet thick, about 270 feet above the sea, and nearly 200 feet above the river, which appears to be an outlier of the gravel just described.

On the east of the Test, opposite the high gravels of Shootash, extensive gravel-covered surfaces occur at from 80 to 100 feet above the river, between which and a lower level of gravel a well-defined step is observable. About Redbridge there are gravel flats at a low level, which, towards Southampton, appear to join the sheet of gravel which covers the sloping tableland, and extends up to the escarpment.

Bordering on the Itchen, between Bishopstoke and Swathling, is a great bed of gravel at about 20 feet above the river. Lower down the river, where it traverses the high ground, there are gravels at the same level, cut off from the gravel covering the plain by a bare slope. Near the confluence of the river with Southampton Water the gravel covering the tableland and the valley-gravel of the Itchen appear to join.

To the east of the Hamble river the tableland of Titchfield common is separated from the lower ground of Chilling and Brunage by a tolerably well-defined step, which extends beyond the Titchfield river, and is shown in section No. 7 from Brunage and section

No. 8 from Stubbington, northwards. Titchfield common and the tableland about it is gravel-covered; but this appears not to be the case with the corresponding level between Titchfield and Fareham. The lower level of Brunage, Hill Head, Stubbington, and Alverstoke is almost uniformly covered with gravel or brick-earth. The section which is seen in the cliff between Hook and Browndown has been well described by Mr. Evans *; the cliff is everywhere less than 40 feet above the mean sea-level, and the gravel in several places reaches as low as high-water mark.

From Browndown a low inland cliff, which rises above the shingle of the rifle-ranges, runs inside the fortification-ditch as far as the railway at Anglesea, and marks the boundary of the gravel which covers the level of Lee, Grange, and Alverstoke. Between this cliff and the shore lies a level tract more than three miles long and a quarter of a mile wide, and but little above high water. The structure of the shingle composing it was exposed in extensive excavations made to obtain materials for the concrete blocks for the Spithead forts. It is evidently a recent beach-deposit due to existing conditions. It has not the coherence or the ferruginous colour of the gravel in the cliffs of Brunage and Lee, from which it also differs in containing numerous oyster and other shells; but the materials are the same, flints but little rolled, with frequent seams of sand, and in general structure there is a good deal of similarity.

About Portsmouth a low gravel-covered flat, which is apparently a continuation of that on the Gosport side of the harbour, extends to the base of the chalk range of Portsdown Hill, to the east of which the lower level is again divided from a higher gravel-covered surface 140 feet above the sea by a slope. Section No. 9 through Hayling Island, and passing half a mile to the west of Bourne Common, to which point the westward extension of the Brighton beach has been traced by Mr. Prestwich †, shows a very similar outline to the sections near Titchfield (Nos. 7 & 8). Still further eastward are the remains of the old sea-bed at Avisford and Waterbeach ‡ with marine shells at from 80 to 100 feet above the sea-level, to the south of which lies the low ground of Selsea, covered with marine gravel containing large blocks of syenite, porphyry, granite, &c. and overlying the mud-deposit of Pagham §, which contains littoral shells of southern species, with remains of *Elephas antiquus* ||.

(*c*) The gravel varies but little in character or composition over the area which has now been described; it consists almost exclusively of chalk flints, little rolled and often perfectly fresh. There is always, however, a proportion of tertiary pebbles; and where, as between Bournemouth and Christchurch, extensive pebble-beds occur in the underlying tertiary strata, the proportion of pebbles in the

* Quart. Journ. Geol. Soc. vol. xx. p. 188.

† Quart. Journ. Geol. Soc. vol. xv. p. 215.

‡ Ibid.

§ *Vide* Mr. Godwin-Austen, Quart. Journ. Geol. Soc. vol. xiii. p. 50, and Sir C. Lyell's 'Antiquity of Man,' p. 281.

|| The Rev. O. Fisher believes (Geological Mag. vol. i. p. 140) that the remains of *E. meridionalis* are also found in this deposit.

gravel is considerable. Fragments of sarsen, or grey-wether sandstone, are met with everywhere, and blocks of considerable size are found in the gravel of the cliffs between Southampton Water and Gosport, and near Southampton, at 170 feet above the sea. A block of puddingstone, part of a larger mass, which is stated to have come from the gravel of Hordwell Cliff, is now in the Jermyn-Street Museum. Mr. Godwin-Austen* has recorded the presence of waterworn specimens of white quartz, granite, and porphyry in the gravel on the high plain a little to the east of Poole, at about 160 feet above the sea; and white quartz-pebbles certainly occur as far east as Lymington. In the gravel covering Portsea Island, at a level not much above high water, numerous blocks of granite, syenite, and greenstone, as well as of sarsen-stone, are found. They are to be seen lying in the gravel-pits near Southsea, where the gravel is at least 27 feet thick, and covered with brick-earth, and in the excavation for the sewers they were frequently met with. They are rounded and smoothed boulders, from 1 to 2 cubic feet in size, and have undergone a partial decomposition, which renders them brittle. They do not appear to extend to the gravel on the west of Gosport, which is but little higher in level. They are probably derived from the same source as the similar boulders of Pagham and Bracklesham, namely, from rocks on the French side of the channel.

Brick-earth of a sandy nature is generally interstratified in the gravel in lenticular seams, and sometimes overlies it. The bedding is generally even and free from disturbance or contortion; and it is to be remarked that the contortions and foldings of the brick-earth and gravel usually attributed to glacial action are met with only at comparatively low levels. In the low gravel-cliffs to the south of Christchurch, near Brunage, and in a gravel-pit near Anglesea (Pl. XXXVII. fig. 14) the characteristic convolutions are seen; but the height at these places is not more than 30 feet above the sea.

At heights ranging to 200 and 300 feet above the sea, the gravel is sometimes folded, apparently from the unequal wasting and subsidence of the clay or marl on which it lies. There is an instance of this near Chilworth "Tower of the Winds," at 300 feet above the sea, where the Bracklesham clay has so wasted and subsided (fig. 15). This action is more commonly observable at the edges of the plains, and in some cases from this cause the bedding of the gravel has been entirely effaced.

The general colour of the gravel is a deep red-brown; there is, however, a white gravel (so known locally and distinguished from the red or binding gravel) which is often met with and deserves some notice. It generally overlies the red gravel and penetrates it in pot-holes and pipes. It is loose and sandy, and the flints in it are white, with a curious porcelain-like lustre. The sandy matrix is sometimes dark with vegetable matter, and there is often a black carbonaceous band between the white gravel and the red (*vide* fig. 15). I believe that generally the white gravel has been formed *in situ*, and that its

* Quart. Journ. Geol. Soc. vol. xiii. p. 45.

origin is due to the bleaching-action of water holding organic matters in solution upon the red peroxide of iron, by reducing it to a soluble protoxide in the way pointed out by Bischoff*. The pipes of white gravel penetrating the red, and the black carbonaceous band separating the two gravels, are usually full of root-fibres. Where, as in some sections, the white gravel seems to be interstratified in the red, it is probable that an unseen pipe communicates with a more sandy and porous seam, which has been bleached, while the less porous gravel over it has been unaffected. In some instances, however, it appears as if the white gravel were a subsequent deposit. In a section in a brick-yard to the east of Lymington the red gravel seems to have been cut away before the white was deposited on its flank. In the chines or bunnies to the west of Bournemouth there are sections at right angles to the coast showing the red gravel with brick-earth over it, ending against a slope of Bagshot sand on the land side and thinning out towards the sea, so that the white gravel which overlies both overlaps the brick-earth, and rests directly on the red gravel, reduced to less than half its thickness in the sea face of the cliff. In the east side of Allum Chine the white gravel is seen overlapping both brick-earth and red gravel, and resting directly on the Bagshot sand. These appearances are not, however, inconsistent with the supposition that the white gravel is contemporaneous with the red, and has been bleached in the way above noticed in consequence of its porosity.

The occurrence of white gravel over red in the south-west of Sussex is noticed by Mr. Martin †, and by Mr. Godwin-Austen ‡, both gentlemen considering the white gravel to be the newer, and a distinct deposit from the red gravel.

The gravel varies much in thickness. On the plains at high levels sections are rare, but the depth does not generally appear to exceed 5 or 6 feet. On the edges of the plains bordering on the valleys, and on the terraces which occur a little below the level of the plains in the larger valleys, the thickness is greater. In the railway-cutting one mile south of Wimborne, through a plain 176 feet above the sea, the gravel is as thick as from 25 to 30 feet. Where the junction of the gravel with the underlying formation is exposed in long sections, it is seen to be much more irregular than the surface. There are instances of this in the railway-cutting near Wimborne, and in that through the level plain between Christchurch and Bournemouth, where the gravel varies from 2 to 12 feet in thickness in 20 yards. In the cliff-sections similar variations are observable; but the average thickness in them and in the gravel-pits in the neighbourhood is about 10 feet. In the Barton and Hordwell Cliffs the gravel is 15 or 18 feet thick, but it thins out, as before noticed, to 8 or 9 feet in pits near the coast, and to 5 or 6 feet more inland. On the plains about Beaulieu, and on the eastern side of Southampton Water, 6 or 7 feet appears to be the average thickness, while at low levels, as in the cliff-section between Southampton Water and Gosport, it is

* Chemical and Physical Geology, vol. i. p. 166.

† Quart. Journ. Geol. Soc. vol. xii. p. 136. ‡ Ibid. vol. xiii. p. 48.

generally 10 feet, and sometimes 15 or 16 feet, and in a pit near Southsea at least 27 feet thick, extending to below the sea-level.

(*d*) No organic remains have hitherto been found in the gravel covering the plains. Mr. Trimmer, who carefully examined the New Forest and the neighbouring country, observes that he found neither shells nor mammalian bones, nor could he hear of any having been found in the gravel*. Mr. Wise, in a recent work on the New Forest†, notices the same absence of mammalian remains. He records the finding of the *os innominatum* of probably *Bos longifrons*; but the locality was Shepherd's Gutter, near Bramshaw, on low ground, and in gravel perfectly distinct from that covering the plains. In the valley-gravels mammalian bones &c. have been found. The rich collections made from the gravels of the Avon and Wily, near Salisbury, are well known. At Fordingbridge, ten miles below Salisbury, on the Avon, the teeth of *Elephas primigenius* have been found in gravel about 40 feet above the river, in which also were imbedded several flint implements now in the Blackmore Museum at Salisbury.

In gravels of the Stour valley near Blandford, 50 feet above the river, elephant- and horse-bones and teeth were found in some abundance‡.

At Dewlish, situated on a tributary of the Trent or Piddle, which flows into Poole Harbour, the bones, molars, and tusks of *Elephas meridionalis* were found in 1813 in a pit on the side of a chalk hill 100 feet above the base. A molar is preserved in the Blackmore Museum, in the guide to which§ Mr. E. T. Stevens quotes the notice of the discovery given in the 'Monthly Magazine' for May 1814.

At Swathling, near Southampton, in the valley of the Itchen, a molar of *Elephas primigenius* was discovered a few years since in gravel about 10 feet above the river, and is preserved at the Fleming Arms Inn.

Flint implements have been found in the tabular bed of gravel capping the cliffs near Bournemouth at 120 feet above the sea-level; of these, one or two were found *in situ* by Dr. Blackmore. In the Christy collection is a cast of a large oval implement from near Lymington; and recently two specimens have been obtained from gravel-pits on Southampton Common at 86 and 150 feet above the sea-level. From the gravel cliff between Southampton Water and Gosport numerous specimens have been obtained. With one exception these were picked up on the beach, on which they evidently had been rolled; but the sharp angles appear to have been smoothly rounded off before the rougher rolling on the modern beach took place. With few exceptions they have the whitish coating and porcelain-like lustre of the flints in the white gravel already described; and as the white coating has been removed at the angles by the

* Quart. Journ. Geol. Soc. vol. vii. p. 25.

† The New Forest, &c. By J. R. Wise.

‡ Forbes's Memoir on the Fluviomarine Tertiaries of the Isle of Wight.

§ Flint Chips, p. 20.

beach-rolling, it would seem that the implements are derived from the white gravel. At Bournemouth also they are generally white, so that it would appear that on the Hampshire coast the implements lie near the top of the gravel, and not, as is generally the case, near the base.

III. The Isle of Wight.

The general features of the Isle of Wight are well known. A chalk range running east and west, and attaining an elevation of nearly 700 feet, divides the island into two nearly equal parts, and is traversed by three river-valleys, at Freshwater, at Newport, and at Brading. More than three quarters of the island is drained by the rivers thus flowing northward to the Solent and Spithead.

(*a*) In the northern part of the island the flat-topped hills are capped with flint-gravel at from 100 to 300 feet above the sea; and though the evidences of a once continuous gravel-covered tableland are not so plain as on the mainland, section No. 10, from St. George's Down to Norris, shows how the gravel covering the hills coincides with a plain having a uniform slope towards the north. Detached patches of similar gravel on Hempstead Cliff, 200 feet, and on Headon Hill, 390 feet above the sea, may also be looked upon as remnants of a tableland comparable to that on the mainland, but sloping northwards.

The gravel differs but little from that on the mainland. It contains, however, besides chalk-flints and tertiary pebbles, Upper-Greensand chert and materials from the Lower-Greensand beds. In the gravel on the cliff near Egypt, to the west of Cowes, at about 130 feet above the sea, I found a large liver-coloured pebble evidently derived from the New Red Conglomerate beds. This, with the white quartz and granitic pebbles already noticed as occurring in the gravel at Lymington and on Poole Heath, establishes a connexion with country far to the westward, which is worthy of notice.

As on the mainland, neither shells nor bones of any sort have been found in this gravel, though the valley-gravels have afforded mammalian remains in some abundance; Mr. E. P. Wilkins, of Newport, records* the discovery in the gravels of the Medina valley of teeth and bones of the mammoth, rhinoceros, horse, ox, deer, and hog.

(*b*) To the south of the chalk range there are gravels which, though lying at considerable elevations, do not appear to be fragments of a tabular surface, but rather to be high-level gravels connected with the rivers which drain the southern part of the island, and flow northward through the chalk range. Such is the gravel on Blakedown, 270 feet above the sea and 170 feet above the adjacent stream, and that at Whitcomb, 260 feet above the sea and 160 feet above the stream.

With them may be also classed the deposit of gravel and loam which caps the cliffs between Blackgang Chine and Compton Bay.

* Geology &c. of the Isle of Wight, p. 7.

Near the former place it attains a height of 300 feet above the sea, and undulating with the cliff-section, it falls as low as 50 feet opposite Compton Grange, rising again to 100 feet to the west of this, where the gravel thins out; but the overlying brick-earth is continued for some distance further. The gravel consists of flints, with chert and ironstone; it contains sand-seams, and is overlain by evenly bedded brick-earth. To the east of Brook Chine the gravel is as much as 15 feet thick, and the brick-earth 12 feet.

At two points in this deposit, at about 100 yards east of Grange Chine, between 60 and 70 feet above the sea, and at half a mile east of Brook Chine, and about 96 feet above the sea, Mr. Wilkins informs me that remains of *Elephas primigenius* have been found. In both cases they were from the gravel continuously capping the cliff, and not in valleys connected with the Chines.

At a small Chine called Sheppard's Chine, a mile west of Brook, are the peaty beds with hazel-nuts and twigs, which have been often described as lying beneath the gravel*. In August, 1868, it was plain that these beds were in a hollow in the gravel, which was 2 feet 6 inches thick beneath them. Over the seams of sand containing vegetable matter lies 5 feet of sandy brick-earth.

(*c*) Within two miles of the western end of the deposit which caps the cliff continuously from Blackgang Chine, are the mammaliferous gravels of Freshwater, which were described by Mr. Godwin-Austen in Forbes's Memoir; and his description in 1853 corresponds well with the section now exposed. The lower beds contain subangular chalk-flints, with much lower cretaceous ironstone and chert, and bands of coarse sand, the whole stained of a red-brown colour. These beds rest on the chalk, and against a rearranged formation of chalk-flints in a chalky paste, which is perhaps a talus formed by subaërial weathering of the chalk before the deposition of the gravel. A curved line sloping steeply towards the valley separates the lowest beds from a similar gravel of a lighter colour, which is not always to be clearly distinguished from the former. A third gravel is again sharply divided from the second by a curved line sloping towards the valley. It is finer, more sandy, with much cross bedding, and contains many small white chalk-pebbles; and it was in this that the molar of *Elephas primigenius*, now preserved at the Albion Hotel, was found at a few feet above high-water level. Over all the gravel-deposits lies a stratum of brick-earth from 4 to 13 feet thick, containing seams of angular fragments of flint, which reaches a height of about 60 feet above the sea towards the Fort. On the east side of the valley another molar of *Elephas primigenius* was found in the gravel, and there are many shells of *Succinea* and *Pupa* in the overlying brick-earth.

(*d*) There is here exhibited in a sea-cliff a complete section across a river-valley with its gravels; and the direction in which the river flowed was clearly from the southward, and seaward. The

* *Vide* Webster in Sir H. Englefield's 'Isle of Wight;' Geological Survey Map and Memoir; Mr. Bristow in Forbes's Memoir on the Fluviomarine Tertiaries of the Isle of Wight; Mr. Godwin-Austen, Quart. Journ. Geol. Soc. vol. xi. p. 116.

presumption would be strong that the river flowed in the same direction as the present stream, were there no evidence in the materials of the gravel to show that the river ran through the Lower Greensand and Wealden beds. In considering what extent of land existed to the southward of the present coast-line when these gravels were formed, a comparison with the very similar valley at the eastern end of the island gives indications worth notice. At Freshwater a stream rises close to the beach, at a level below that of high water, and flows northward to the Solent, by Yarmouth. At the other end of the island the Brading river has two branches, one rising at the back of a beach protected by groynes, in Sandown Bay, and flowing for its entire course below the level of high water; and the other draining a considerable area towards Arreton and Niton.

Mr. Godwin-Austen has observed* with regard to the Sandham level, which constitutes that part of the valley of the Brading river which is below high-water level, that excavations for deep drains show no signs of estuary deposits, or evidence of the sea having formerly occupied it; and the same observation applies to the Freshwater valley. Not only is there no evidence that the sea has ever occupied these valleys, now not much above half-tide level and artificially protected from the sea, but the succession of gravels down to the sea-level seems to prove that both valleys have been gradually deepened by fluviatile action only.

Both valleys traverse the chalk under similar circumstances; the thickness is the same, and the strata are nearly vertical. Fig. 13 (Pl. XXXVII) shows the transverse sections of the two valleys through the chalk drawn to the same scale, and if the sectional areas may be considered as roughly proportional to the extent of the river-basins, the ancient Yar was at least as important a stream as the Brading river. The latter at present drains 24 square miles, to the south of the chalk range, or $\frac{1}{6}$ of the area of the island; and gravels on the cliffs about Sandown show that the branch of the river which now rises near the beach is the representative of a much larger stream, which, when flowing 100 feet higher, drained land then occupying the position of Sandown Bay. It is therefore not an improbable supposition that the gravel with Elephant remains on the cliffs at Brook and Grange was included in the same river-basin as the Freshwater gravel, and that the streams now entering the sea between Blackgang Chine and Compton Bay were tributaries of a river flowing northwards through the chalk range to the Solent. The difference of level in the gravel is no more than is due to the natural fall of the watercourses, and the waste of the cliffs now going on shows that a considerable area of land has but recently been destroyed.

The chines by which the streams at the back of the Isle of Wight enter the sea are probably due to the alteration in the drainage consequent on the destruction of this land. The streams ending in chines present no unusual features until they come within a short

* Quart. Journ. Geol. Soc. vol. xiii. p. 66.

distance of the coast, when they begin to fall more and more rapidly through a ravine, which has been cut out in the bottom of a valley corresponding in level and cross section, and continuous with that in which the stream flows before it enters the ravine. The increased rate of fall towards the sea is opposed to the general tendency of streams to fall less as they near their outfall, and it seems to point to a somewhat sudden change in the conditions under which the streams flowed. Such a change would result if the streams which were tributaries of a river flowing to the Solent by Freshwater had been provided with new outfalls by the cutting back of the coast-line, until the river and its branches were intersected while still flowing at a considerable height above the sea. If this be the true explanation of the occurrence of the chines at the back of the Isle of Wight, it would seem to be a fair inference that where chines, or bunnies, are found, a similar change in the outfall of the streams has taken place.

(*e*) The section of gravel exhibited in the cliff round Foreland Point, at the eastern extremity of the Isle of Wight, seems to deserve a more detailed description than it has hitherto received, although it has been often mentioned* in notices of the superficial deposits of the neighbouring country.

Fig. 12 (Pl. XXXVII.) represents the section exposed in the coast-line from Whitecliff Bay, round the headland. The main mass of gravel consists of rounded chalk-flints, imbedded in sand and distinctly stratified in layers of pebbles of assorted sizes, dipping slightly northward. The flints, though well rounded, have not the finish of the pebbles in tertiary pebble-beds, and the structure shows it to be a beach-deposit. Seams of pure sand overlie bands of pebbles as large as oranges, and layers of pebbles stained a dark red are succeeded sharply by bands of white pebbles. Pieces of sarsen-stone, and fragments of chert and sandstone from beds below the chalk, are occasionally met with. The thickness is between 30 and 40 feet, extending from a few feet above high-water mark to 60 feet above the mean sea-level. The general colour is a red-brown, and it is only near the overlying brick-earth that there is any admixture of clay or loam.

No organic remains of any sort have been found in this gravel. In structure it is exactly like a beach-deposit, and in many respects unlike the gravel covering the high ground of the north of the island and the mainland.

Gravel of a similar character is said, by Mr. Godwin-Austen †, to occur at St. Helens, and is supposed by that gentleman to be a continuation of the Foreland bed. A deposit of gravel on the shore to the east of Ryde is described by Mr. Bristow ‡ as consisting of "white rounded flint-pebbles in brown clay, precisely similar to

* Forbes's Memoir, p. 6; Memoir of the Geological Survey of the Isle of Wight. p. 103; Godwin-Austen, Quart. Journ. Geol. Soc. vol. xi. p. 116; Prestwich, Quart. Journ. Geol. Soc. vol. xv. p. 215.

† Forbes's Memoir on the Fluviomarine Tertiaries of the Isle of Wight, p. 7.

‡ Memoirs of the Geological Survey of the Isle of Wight, p. 102.

those found on a modern sea-beach." A somewhat similar gravel of rounded flints of considerable size is also noticed by Mr. Bristow as occurring in the valley of King's quay, between Ryde and Cowes.

The mass of shingle-gravel at the Foreland thins suddenly towards the south, and is overlain by 36 feet of brick-earth containing a few seams of small angular flints, which thins rather abruptly to 6 or 8 feet, and caps the edges of the Eocene beds nearly to the chalk range, reaching a height of 100 feet above the sea. A similar brick-earth, with more or less of angular flints, appears at heights up to 100 feet at many points over the Bembridge peninsula. At a point marked on the section (fig. 12), in the brick-earth a little to the south of the thick mass, I found a flint implement of the oval type. It lay within a few feet of the top of the cliff, or rather of the broken slope of marl, which at that point reaches 85 feet above the mean sea-level. It was with a few other flints which had recently become detached from the brick-earth, of which the implement still bore traces. Unlike the great majority of those from the gravel of the Hampshire coast, it is perfectly sharp in the angles of the chippings.

The brick-earth, where it thins out over the thick mass of shingle-gravel, is eroded and overlain by a drab-coloured loam, which caps the shingle-gravel throughout, and extends partly over the other deposits to be noticed further on. A little to the north of the Coast-Guard Station, where the cliff loses height, the deep red-brown shingle-gravel is overlain by a white shingle, the junction being slightly irregular, and dipping about 3° northwards. In a short distance a peat-bed appears beneath a more clayey gravel, which takes the place of the white shingle; just beyond, a bed of brick-earth is interstratified in the gravel, and about a quarter of a mile from the first peat-bed another and larger one occurs. The two deposits are so much alike in character and situation, as to render it probable that the same bed is seen at two points. At a few feet above high-water mark the Bembridge marl is covered by a few inches of dark grey clay with black pebbles, on which the peat-bed lies, and is covered by 6 inches of grey clay, succeeded by a red clayey sand passing up into a clayey pebbly gravel. The peat-bed does not much exceed a foot in thickness; it is described by Mr. Godwin-Austen, who examined it with Professor E. Forbes, as having the usual characteristics of accumulations of vegetable matter in damp situations, and containing the remains of large trees, hazel-nuts, and beetles*. The top of the cliff where the peat-beds are is less than 25 feet above the mean sea-level, and the gravel is much more clayey than the pebble-gravel proper, and confused in the bedding. Beyond the second peat-bed, towards Bembridge, the cliff again rises, and the gravel is again evenly stratified clean shingle.

In this section the shingle-gravel is clearly the oldest, and at the time of its accumulation the highest part must have been near the sea-level. It may with probability be looked upon as the equivalent

* Quart. Journ. Geol. Soc. vol. xi. p. 116.

of the Brighton Beach, the extension of which has been traced westwards by Mr. Prestwich* to Avisford, Goodwood, and Bourne Common, fourteen and a half miles to the N.N.E. of the Foreland gravel†. The brick-earth corresponds in position with the rubble-bed with elephant remains over the old beach at Brighton, and with the similar bed with land shells over the Sangatte beach. The main mass appears to fill up an old channel cut through the shingle, and its highest part could hardly have been deposited much above the level of the sea, which, as the shingle shows, must have been near. A rise of land to the extent of 70 or 80 feet appears, therefore, to have taken place since the deposition of the brick-earth in which the flint implement was imbedded. The peat-beds, and the gravel and brick-earth over them, must have been formed at or above their present level and subsequent to the upheaval.

IV. General Considerations.

In entering upon the consideration of the conditions under which the gravels of the district now under notice were deposited, it will be convenient to take as a starting-point the great gravel-covered flat of southern Sussex. The marine character of this gravel has been shown by Mr. Dixon‡, Mr. Godwin-Austen§, and others. At Pagham, Bracklesham, and Selsea it overlies the mud-deposit with shells of southern species (*Pecten polymorphus* &c.) and the remains of *Elephas antiquus*, and contains ice-transported boulders of granite, porphyry, syenite, and palæozoic rocks. The gravel covering Portsea Island is the same in level, and also contains similar boulders. Passing across Portsmouth Harbour, the gravel between Gosport and Southampton Water lies at the same level, and is apparently a continuation of the others. It presents, however, a more fluviatile appearance, and large blocks of sarsen-stone brought down from inland, and lying in contorted gravel, take the place of the granitic boulders of Selsea and Portsea, and are equally indicative of the glacial conditions under which the beds were deposited.

To the northward of this low tract lie the beach-deposits described by Mr. Prestwich ||, containing marine shells at from 80 to 100 feet above the sea-level at Waterbeach, near Goodwood, and extending westward to Bourne Common; the high ground, with gravel, shown in section No. 9; and, passing by Portsdown Hill, which rises immediately from the low ground, the corresponding level shown in sections Nos. 8 and 7, separated from the lower tract by a steeper slope or step.

* Quart. Journ. Geol. Soc. vol. xv. p. 315.

† There seems to be some reason to believe that a raised beach may exist at Bonchurch. Mr. Wilkins mentions the fact that the jaw-bone of a young whale and part of the skull of an elephant were found in drift at Horseshoe Bay.

‡ Dixon's Geology, &c., of Sussex.

§ Quart. Journ. Geol. Soc. vol. xiii. p. 50.

|| Quart. Journ. Geol. Soc. vol. xv. p. 215.

The old sea-bed of the Sussex level, then, appears to pass between the old coast-line thus marked out on the north, and the beach-deposits of the Foreland, St. Helens, &c. along the coast of the Isle of Wight, becoming more like a river-gravel in character, and containing numerous flint implements in its westward extension. The supposition that there was here an estuary through which the rivers from the westward reached the sea when the Isle of Wight was still joined to the mainland, derives support from other considerations.

(*a*) The connexion of the island with the mainland, which is obviously suggested by the continuation of the chalk range of Purbeck through the island, appears to have existed down to recent times. The ten-fathom line, which is within half a mile of the coast all along the back of the Isle of Wight, strikes across Christchurch and Poole Bays to Handfast Point, following the course of the vertical chalk strata, and again hugs the shore round the Purbeck coast. Inside this line the sea is generally less than five fathoms deep, and is steadily encroaching on the land at the rate of about a yard in a year. At this rate the coast would have receded from the line of the chalk to its present position in about 9000 years. This is of course but a rough estimate of time, but it shows the probability of a connexion by which the Mammoth and tichorhine Rhinoceros had free access to the Isle of Wight down to the time of the lower valley-gravels, in which their remains are far from rare.

The Chines, or bunnies, along the coast between Hordwell and Poole appear to show that a change has taken place in the course by which the streams reached the sea, as has been already pointed out. The extensive mud-flats more than a mile wide along the north shore of the Solent must, as Mr. Godwin-Austen has observed*, have originated in a very different condition of the Solent from the present, and they also point to the comparatively recent time at which the condition was that of an estuary, in which the formation of such mud-flats would have been natural.

When a continuous range of chalk downs stretched along where the ten-fathom line now lies between the Needles and Handfast Point, the river system was most probably analogous to that which now exists. All the streams which traverse the chalk of the Isle of Wight and Purbeck, flow northwards from the older beds into the Tertiary basin; and it appears unlikely that the rivers which now enter the sea at Poole and Christchurch took an opposite course through the chalk. It is natural to suppose therefore that the Frome and Piddle continued their easterly course inside the chalk range in a joint stream, of which the Avon and Stour were affluents, and which received tributaries draining country up to, and perhaps beyond, the chalk on the south, as the Corfe River, the Medina, and the Brading river still do. The rivers flowing into Southampton Water joined those coming from the westward by way of the Solent, and formed a broad estuary communicating with the sea by Spithead.

* Quart. Journ. Geol. Soc. vol. xiii. p. 65.

(*b*) Mr. Prestwich has correlated* the Brighton beach and the Sussex gravel-beds with the estuarine beds of Menchecourt, and has also remarked† on the close resemblance which the Menchecourt beds bear, marine characters apart, to those at Fisherton, near Salisbury. The flint implements from the coast between Gosport and Southampton Water bear a corresponding resemblance to those from Fisherton and from Menchecourt. The ovoid type greatly predominates; and where, as at the Blackmore Museum, a large number of implements from the Hill Head gravels can be compared with a series from Fisherton, and from Milford Hill, near Salisbury, the general resemblance of the Hill Head and Fisherton specimens to each other and to the Menchecourt type, and the different character of the Milford Hill implements, and their resemblance to the spear-head form common at St. Acheul, are equally manifest. Adopting the supposition that the Avon flowed to the sea by Spithead, it is not difficult to trace a connexion between the Sussex and the Hill-Head gravels and the Fisherton beds. The gravel bordering on the north shore of the Solent carries on the Hill-Head gravel to Lymington, where an oval flint implement has been obtained from it, and on to Milford. Beyond this the coast is exposed to the open sea, and has been cut back, so that none of the lower level remains until the Avon valley is reached, six miles to the westward. There contorted gravel and brick-earth are seen in the cliff-section of the old river channel beyond Hengistbury Head, at from 20 to 40 feet above the sea-level, and thence the connexion of the valley-gravels up to Salisbury is plain. The plateau of Beaulieu Heath, which is about 70 feet above the lower gravel on the north of the Solent, and which corresponds in level and position to Titchfield common, stretches continuously to Poole, broken only by the river-valleys, as is shown in section No. 2. In the gravel covering of this tableland the flint implements of Bournemouth are imbedded, and it seems probable that the gravel of the plains at this level near the coast may correspond in age with the high-level valley-gravels, as it does in position with regard to the lower valley-gravels.

Having thus a sort of datum-line with which to compare the levels of the gravel covering the plains, it appears that while near the coast the tableland is but 50 or 60 feet above the lower valley-gravels of the Avon, at Fordingbridge it is 250 feet higher than beds with flint implements and *Elephas primigenius*, which lie about 40 feet above the river; and when the tableland attains its greatest elevation near Bramshaw Telegraph, it is 240 feet above the Fisherton beds in actual level, or if the plain were prolonged at the same inclination it would pass 400 feet above the Fisherton beds, and 320 feet above the top of Milford Hill at Salisbury.

It is remarkable that the inclination of this tableland, if prolonged still further, is found to touch the highest points of the country up to the source of the Avon; namely, Dean Hill, and Beacon Hill, Milk Hill, and Martinsell on the north of the vale of Pewsey.

* Phil. Trans. 1864. † Phil. Trans. 1860.

An argument for the great antiquity of the gravel of Milford Hill, at Salisbury, with its imbedded implements, has been justly based on the circumstance that since it was deposited the valley of the Avon has been deepened some 80 feet, and that after by far the greater part of this deepening had been accomplished, the Mammoth, Rhinoceros, Lion, Hyæna, Marmot, Lemming, &c. left their remains in the Fisherton beds. The same line of reasoning shows the far greater antiquity of the gravel on the higher plains of the New Forest, of that on both sides of the Itchen, near Southampton, and near Newport, in the Isle of Wight, more than 250 feet above neighbouring valley-gravels containing *Elephas primigenius*, &c.

(*c*) But if the great height attained by the gravel-covered plains is evidence of an antiquity far greater than that of the Milford Hill, and other high-level valley-gravels, the uniform surface of the tableland points to a continuance of similar conditions from the time of deposit of the highest gravels down to that of the gravel containing flint implements at Bournemouth, Lymington, Hill Head, &c. What these conditions were is open to question; there are no organic remains by which to decide whether the gravel covering these wide plains is an extension of the gravels of the neighbouring rivers, or a marine deposit, like that covering the southern part of Sussex.

It has already been pointed out that, probably down to the time of the low-level valley-gravels, the Isle of Wight was connected with the mainland, and a river, comprising in its drainage-area the basins of the rivers now reaching the sea at Poole, at Christchurch, and by Southampton Water, flowed by Spithead to the sea. Fig. 11 is a map of the catchment basins of the rivers in question*. The area drained by all the rivers entering the sea from Poole to Portsmouth, together with the Isle of Wight, and Christchurch and Poole Bays, out to the 10-fathom line, is 2750 square miles, equal to $\frac{3}{4}$ the area of the basin of the Thames above Hampton. Of this area, 666 square miles, or nearly $\frac{1}{4}$, is comprised in the basin of the Avon, 544 square miles in that of the Test, and 479 in that of the Stour; while only 331 square miles, or less than $\frac{1}{8}$, is drained by the rivers entering Poole Harbour. The hydrographical area of the old river appears therefore to have been comparatively small, and but little augmented by the western river-basins. Within it, however, lie the large gravel-covered surfaces which have been described. Of these the New-Forest tableland alone slopes in the direction of the principal lines of drainage; it occupies the watershed between the Avon and the Test, and falls in the direction of their flow at the rate of from 18 to 34 feet per mile. The tableland on the east of Southampton Water slopes at the rate of from 30 to 120 feet per mile towards the water, and the Isle of Wight tableland at from 30 to 40 feet per mile northward. The flattest of these inclinations, that of the New-Forest tableland, is, for the course of a river, very great, and such as only mountain-

* Reduced from the Map to accompany the Report on Salmon-Fisheries, 1861.

streams have*. It is difficult to conceive that a river flowing with the velocity due to such a fall could have spread out the gravel over these wide even surfaces more than 20 miles across ; and the various directions in which the tablelands slope forbid the supposition that any part of the present inclination is owing to a subsequent tilting up of the land.

It is perhaps a more probable hypothesis that the spreading out of the gravel and the levelling of the plains took place in an inlet shut in on the south by high land and opening out to the eastward. If this were the case, the land at the time of the deposition of the highest gravels now remaining must have stood 420 feet lower ; and this may have been in some degree contemporaneous with the great depression of the Boulder-clay epoch. A deposit thus formed of materials brought down from the chalk country on all sides would be entirely local in character; but the apparent absence of indications of glacial conditions in the gravel, except at levels so low as to correspond with valley-gravels, is not easy of explanation.

(*d*) The raised shingle of the Foreland, the marine gravel of the south of Sussex, and the beach-deposits with sea shells at Avisford and Waterbeach are evidences that at a time geologically recent the land stood 80 or 100 feet lower. Flint implements, however, are found imbedded in gravel 120 feet above the sea on the Bournemouth cliffs, and 150 feet above the sea on Southampton Common ; and an hypothesis which assumes that man existed when gravels, now 120 and 150 feet above the sea, were forming at or below the sea-level may be on that account alone considered as untenable. But flint implements are found at Menchecourt associated with marine shells at 40 feet above the sea, and at the Foreland under circumstances which seem to show that an elevation of land to the extent of from 70 or 80 feet has taken place since man's appearance; and when it is considered what an enormous amount of change has taken place at Salisbury and elsewhere since the high-level gravels containing flint implements were deposited, and what a vast amount of time such changes imply, it does not appear to be incredible that the upheaval should have been so much as 150 feet.

A considerable alteration in the coast-line must also have taken place. Land must have existed to the south of an inlet such as that supposed, of which the Isle of Wight is but the shadow. Denudation of the surface by subaërial action, and of the coast by the sea, must have gone on *pari passu* with upheaval ever since the high plains were first raised above the sea-level. As the land gradually rose, the effect would have been to contract the inlet and bring it into the condition of an estuary branching into the Solent and Southampton Water. Of these, the latter remains an estuary, while the

* Fall of the Rhine.	Source to Dissentis	60	feet per mile.
„	Dissentis to Constance.........	16	„
„ Rhone.	Source to Brieg..................	52	„
„	Brieg to Lake of Geneva	10	„
„ Clyde.	Source to Lanark	20	„

Solent has become an arm of the sea by the severance of the Isle of Wight from the mainland.

(*e*) The last movement appears, however, to have been one of subsidence. Submerged forests have been observed in Poole Harbour, off Bournemouth, off Southsea Castle, off Pagham, and at Portsmouth. Sir Charles Lyell * adopts the conclusion of the Bishop of Gibraltar, that the Bournemouth forest was submerged by the washing out of a sandy substratum without a general subsidence of the land, and explains the occurrence of the similar deposits on the north side of Poole Harbour in the same manner. The section at Portsmouth, which was described by Sir H. James †, appears, however, to afford good evidence of a downward movement. An old terrestrial surface with rooted trees which, when living, must have stood at least 30 feet higher, was exposed in the dockyard in 1847, and has been again brought to light, but at a higher level, in the works for the extension of the dockyard now in progress. The origin of Poole Harbour and Christchurch Harbour, and of Portsmouth, Langston, and Chichester Harbours, is probably in a great measure due to this subsidence, which, according to Mr. Godwin-Austen ‡, there is some reason to believe has gone on till within the last few centuries.

(*f*) The denudation which the surface of the country has undergone since the deposition of the gravel on the plains is as remarkable for its partial character as for its extent. Large areas of the plains at the highest levels appear to have remained quite unchanged, while close by deep valleys have been scooped out, and high escarpments have been formed by what cannot have been any other than subaërial causes, and while large tracts of land have been gradually removed by the action of the sea on the neighbouring coast-line.

The nature of the geological formation appears to have had no part in influencing the destruction or the preservation of the surface. Barton Clay, Bagshot Sand, and Headon Marls alike underlie the gravel of the New-Forest tableland, and have alike been removed over the area drained by the tributaries of the Boldre river, of which Lyndhurst is the centre. The gravel covering itself is probably the protective agent, and it may have been thinner or more loamy where the old surface has been destroyed.

V. Summary.

The chief points to which attention has been called in the foregoing paper are as follows:—

1. That the gravel plains of the New Forest and the neighbourhood are portions of a tableland rising slightly to the northward and attaining an elevation of 420 feet; and that the remains of similar tablelands exist on the east side of Southampton Water,

* Principles of Geology, vol. ii. p. 530.
† Quart. Journ. Geol. Soc. vol. iii. p. 249.
‡ Quart. Journ. Geol. Soc. vol. vii. p. 118.

and, in a more fragmentary state, in the Isle of Wight, having a slope greater and in other directions.

2. That while the gravel covering these tablelands at the highest levels is of a far greater age than the valley-gravels of the rivers, the gravel near Bournemouth, on Beaulieu Heath, Titchfield Common, and at similar levels appears to be equivalent in position and age to the high-level valley-gravels, and also to the beach-deposits of Avisford and Waterbeach containing marine shells; and that a lower tract of gravel bordering on the northern shore of the Solent and Spithead appears to correspond on the one hand with the low-level valley-gravels of the rivers, and on the other with the marine gravel covering the low land of Selsea.

3. That the spreading out of the gravel, and the levelling of the tablelands, probably was effected in an inlet of the sea shut in on the south side by land which connected the Isle of Wight with the mainland, and opening to the eastward.

4. That a gradual upheaval appears to have gone on from the time of the oldest and highest gravels down to the date of the low-level valley-gravels, by which the inlet was narrowed into an estuary which received the waters of all the rivers from Poole Harbour eastward, the Isle of Wight being still connected with the mainland.

5. That of this upheaval in its latter stages there is evidence remaining in the marine gravel of Sussex, in the raised shingle of the Foreland, and in the beach-deposits of Waterbeach and Avisford.

6. That the flint implements of Bournemouth and Southampton Common are from gravel covering tablelands at elevations corresponding to the high-level valley-gravels, and that the implements from the coast between Southampton and Gosport are from gravel corresponding to the low-level valley-gravels.

7. That the position of the flint implement found above the raised shingle of the Foreland appears to prove that an upheaval to the extent of 70 or 80 feet has taken place since its deposition in the brick-earth; and that if the origin of the gravel covering the plains be as above supposed, the flint implements of Bournemouth show that the upheaval has been as much as 120 feet, and the implements in the gravel on Southampton Common as much as 150 feet, since the appearance of man.

DESCRIPTION OF PLATES XXXVI. & XXXVII.

Plate XXXVI.

Map of the south of Hampshire and the Isle of Wight, with parts of Sussex and Dorsetshire, showing the principal gravel-covered surfaces. The lines of the Section are shown, and the letters refer to corresponding letters on the sections, figs. 1 to 10, Plate XXXVII.

Plate XXXVII.

Fig. 1. Section across the valley of the Avon and the highest part of the New-Forest tableland, through Fordingbridge, Hampton Ridge, and Blackbush Plain, with a section branching at Hampton Ridge and crossing the valley of the Avon at Breamore.

Fig. 2. Section near the coast between Poole Harbour and Christchurch, and following the line of strike of the New-Forest tableland to Southampton Water at Cadland. The continuation of this section on the east of Southampton Water is in the direction of the rise of the surface, and, with figs. 6 and 7, shows the slope of the tableland towards Southampton Water.

Fig. 3. Section from the coast half a mile east of Highcliff to Winckton Post, and continued from a point on the plain 1 mile to the east, to Burley Beacon, where a short branch diverges to Picked Post. The main section again divides at Bratley Plain, the western line crosses two bottoms to Leadenhall and intersects the northern escarpment of the New-Forest tableland, half a mile west of Bramshaw Telegraph. The eastern line traverses Ocknell Plain and Blackbush Plain, and cuts the escarpment 1 mile west of Bramshaw Church. This and the two following sections are in the direction of the rise of the New-Forest tableland.

Fig. 4. Section along two lines from Barton cliff, and from Hordwell cliff to Wilverley, and thence through low ground to the tableland near Stoney Cross.

Fig. 5. Section from the Solent, 2 miles east of Lymington, across Boldre Heath to the escarpment at Ladycross Lodge, and on to Matley Heath. This section shows the prolongation of the tableland down nearly to the sea-level along the Solent, and also the occurrence of detached gravel-topped hills beyond the escarpment.

Fig. 6. Section through Southampton along the Winchester road to Chandler's Ford, with a branch over Chilworth common to the escarpment near the "Tower of the Winds," the highest point of the tableland on the east of Southampton Water.

Fig. 7. Section from the coast between Brunage and Hill Head, and

Fig. 8. Section from 1½ mile east of Hill Head northwards, show the relation of the gravel from which flint implements have been obtained with the gravel on the higher level of Titchfield Common.

Fig. 9. Section through Hayling Island northwards to a gravel-covered surface half a mile west of Bourne Common.

Fig. 10. Section through St. George's Down and Stapler's Heath to Osborne and Norris, showing the coincidence of the gravel-capped hills in the Isle of Wight, with a slope northwards corresponding to the slope southwards on the mainland.

Fig. 11. Map showing the area of the river-basins within which the gravel-covered tablelands are situated.

Fig. 12. Section of the gravel and brick-earth deposits exhibited in the cliff at Foreland in the Isle of Wight.

Fig. 13. Comparative sections of the Brading and Freshwater valleys where they traverse the chalk.

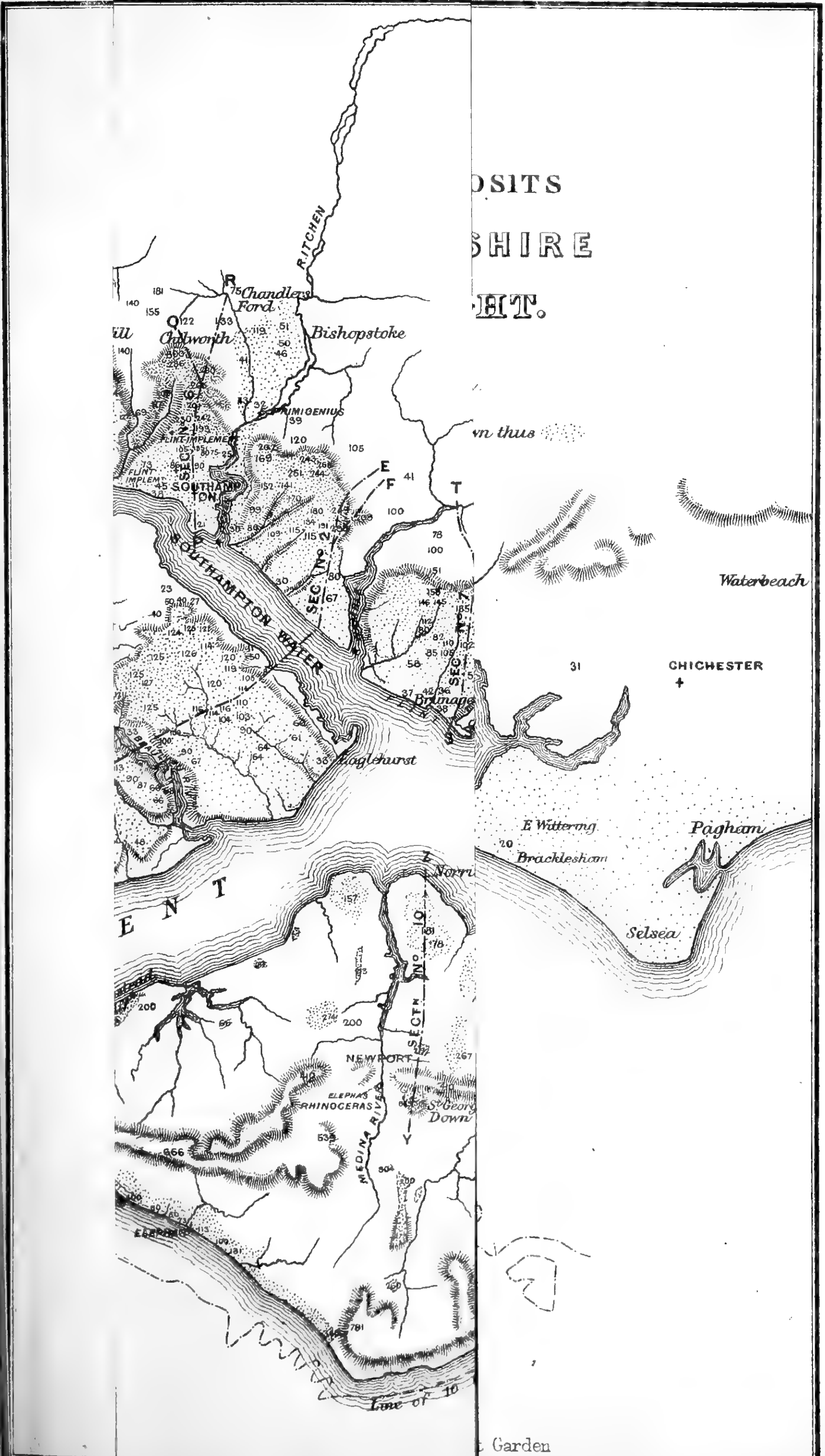
Fig. 14. Contorted gravel and brick-earth in a pit near the railway at Anglesea, about 17 feet above the mean sea-level.

Fig. 15. Gravel in a pit near the "Tower of the Winds," Chilworth, 300 feet above the mean sea-level, where disturbance of the gravel appears to have arisen from the wasting of the beds beneath. The occurrence of white gravel, separated from the red by a black carbonaceous band, is also here seen.

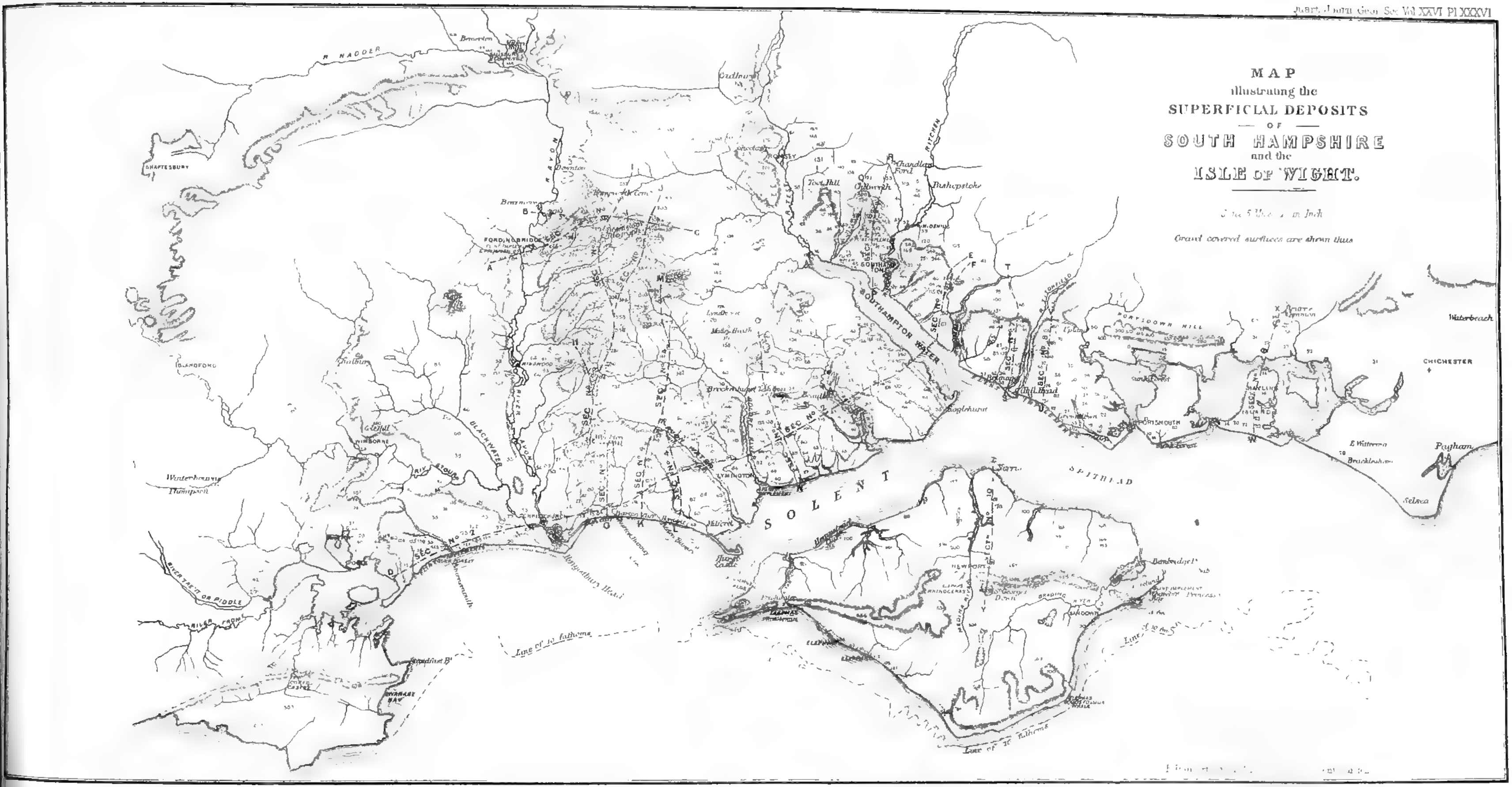
Discussion.

The President referred to the raised beach at Brighton, which he had traced thence as far as Chichester. He inquired what evidence there was of the marine origin and contemporaneity of the beds identified with this beach by Mr. Codrington.

Mr. Whitaker noticed the occurrence of gravels similar to those



OSITS
SHIRE
HT.
RITCHEN
Chandlers Ford
Bishopstoke
Chilworth
PRIMIGENIUS
FLINT IMPLEMENTS
SOUTHAMPTON
SOUTHAMPTON WATER
wn thus
Waterbeach
CHICHESTER
Eaglehurst
E Wittering
Bracklesham
Pagham
Selsea
NEWPORT
ELEPHAS RHINOCERAS
MEDINA RIVER
St George Down
Line of 10
t Garden

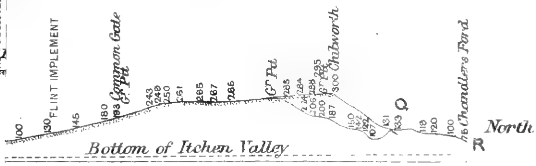

MAP
illustrating the
SUPERFICIAL DEPOSITS
OF
SOUTH HAMPSHIRE
and the
ISLE OF WIGHT.
Gravel covered surfaces are shown thus
SOLENT
SOUTHAMPTON WATER
SPITHEAD
PORTSDOWN HILL
CHICHESTER
SHAFTESBURY
BLANDFORD
WIMBORNE
FORDINGBRIDGE
LYMINGTON
NEWPORT
PORTSMOUTH
Selsea
Pagham
Line of 10 fathoms
Line of 10 fathoms

haw. Section No 3

Black Bush

FIG 6.

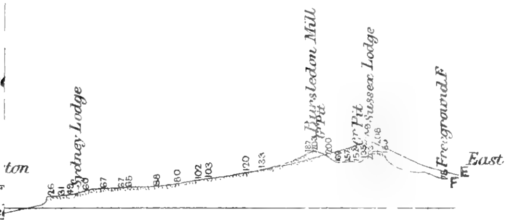
from Southampton to Chilworth, and Chandlers Ford.



m Po

ton

Sea Level



Burley Beacon

Se

FIG. 7.

ion, from Brunage to Curbridge.

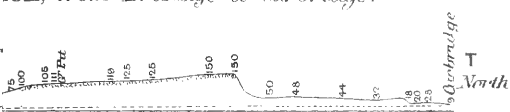


FIG. 8

Section, from Stubbington to Funtley

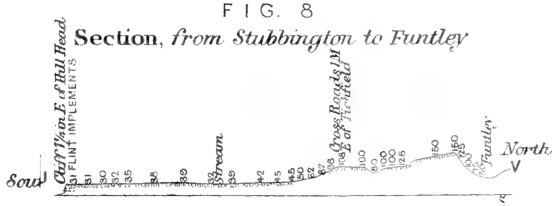
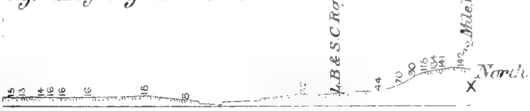


FIG. 9.

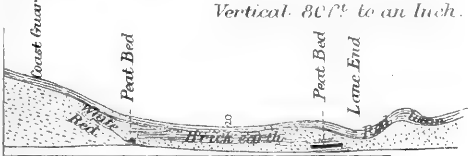
ugh Hayling to near Bourne Common.



G. 12.

n. Foreland I.W.

Scales.–Horizontal 3 Inches to a Mile.
Vertical 80 Ft to an Inch.



Dangerfield lith. 22, Bedford St. Covent Garden

SECTIONS
illustrating the
SUPERFICIAL DEPOSITS
of
SOUTH HAMPSHIRE
and the
ISLE of WIGHT.

Scales – Horizontal 2 Miles to an Inch
Vertical 800 Feet to an Inch.
The heights are figured in feet above the Mean Sea Level
Gravel covered surfaces are shown thus

FIG 1
Section, from Fordingbridge and Breamore to Bramshaw

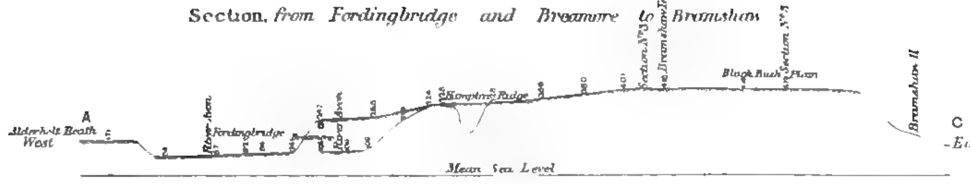


FIG 10
Section, from St George's Down to Norris Castle.

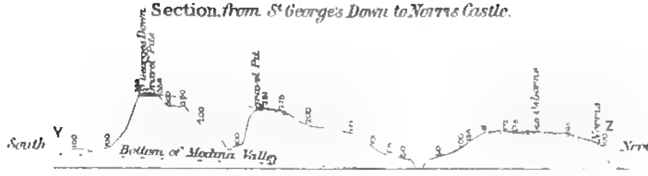


FIG 6
Section, from Southampton to Chilworth, and Chandlers Ford

FIG 2
Section, from Poole Harbour to Southampton Water and Botley Common

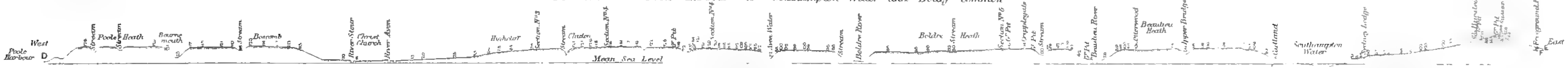


FIG 3
Section, from High Cliff to near Bramshaw Telegraph

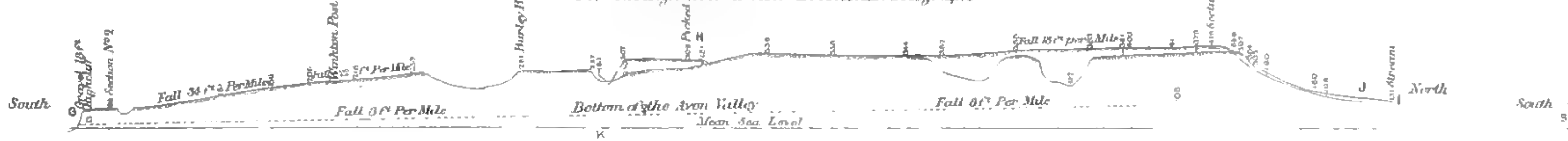


FIG 7
Section, from Brunage to Curbridge

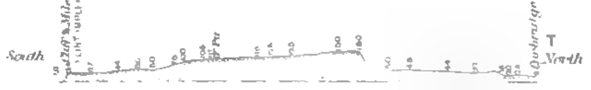
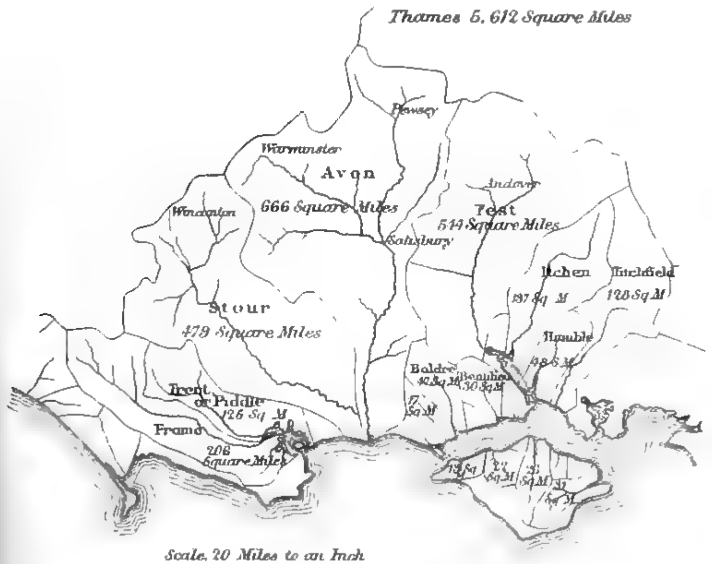
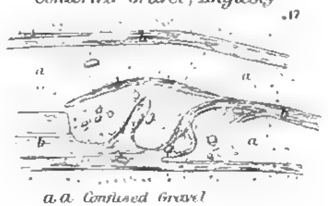


FIG 11
Map of the Catchment Basins of Rivers Avon, Stour, Test &c



Scale, 20 Miles to an Inch

FIG 14
Contorted Gravel; Anglesey



a a Confused Gravel
b b Laminated Clayey Sand

FIG 4
Section, from Barton Cliff and Hordwell Cliff to Stoney Cross

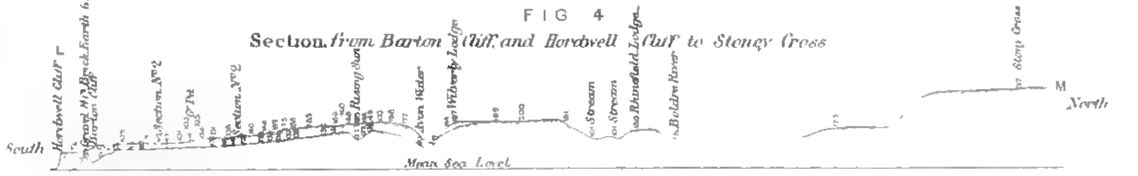


FIG 8
Section, from Stubbington to Funtley

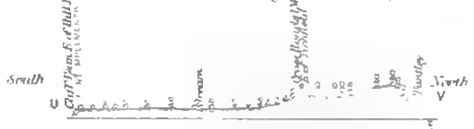


FIG 5
Section, from the Solent to Matley Heath

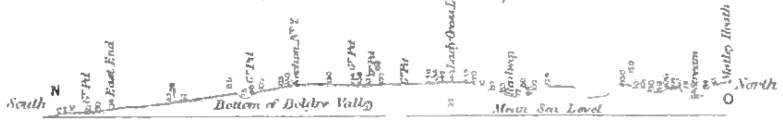


FIG 9
Section, through Hayling to near Bourne Common

FIG 15
Near Chilworth Tower of the Winds.

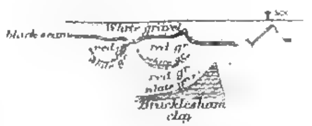
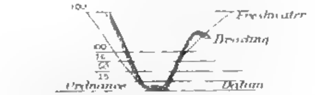


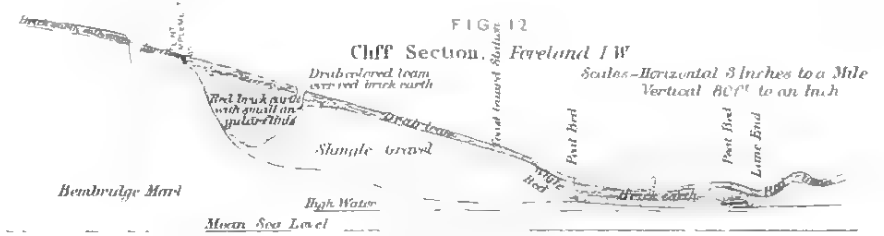
FIG 13
Comparative Sections of Freshwater and Brading Valleys



Scales 4 inches to a mile horizontal
400 ft to an inch vertical

FIG 12
Cliff Section, Foreland I W.

Scales – Horizontal 3 Inches to a Mile
Vertical 80 ft to an Inch



F Dangerfield lith 22 Bedford St Covent Garden

described by Mr. Codrington on the slope between Canterbury and Herne Bay as indicative of the presence of a large river. He agreed with the author in considering that the white gravel was produced by the decolorization of the red; and remarked that it was unusual to find angular gravels of thoroughly marine type.

Mr. C. Moore remarked that the gravels and brick-earths from Salisbury westward are all of freshwater origin, and contain the remains of frogs in great abundance, together with freshwater shells, bones of *Arvicolæ*, &c.

Sir Charles Lyell was inclined to ascribe the formation of the gravels described to the sudden melting of snow in great quantities. He referred to the presence of sarsen-stones as indicating that there was force enough to carry large masses.

Prof. Ramsay referred to the great denudation of Eocene strata which must have taken place before the present form of the land was produced, as implying an immense amount of river-action, the immediate results of which are now masked by the modifications produced by subsequent subaërial changes of more limited extent. He maintained that the finding of flint implements at various elevations only rarely furnished direct evidence of change in the relative level of sea and land.

Mr. Codrington, in reply, stated that the gravels were not valley-gravels such as those mentioned by Mr. Moore. He did not see how glacial action could have spread the gravels over flat tablelands.

---

2. *On the* relative Position *of the* Forest-bed *and the* Chillesford Clay *in* Norfolk *and* Suffolk, *and on the* real Position *of the* Forest-bed. By the Rev. John Gunn, M.A., F.G.S.

At a meeting of the Geological Society, held May 20th, 1868, I stated, in opposition to the view entertained by Mr. Prestwich of the Forest-bed being placed above the Chillesford clay, that I had seen it at Easton Bavent, in Suffolk, upon the beach, at a lower level than the Chillesford clay in the cliff, and also that I had seen it at Kessingland and Pakefield, on the beach and at the foot of the cliff, underlying the Chillesford clay.

I have visited these places several times since; and a fall of the cliffs and the partial clearing away of the beach at Kessingland have exposed the strata in the following ascending order:—The Forest-bed on the beach; the freshwater Unio-bed, similar to those at Mundesley and Runton; the Fluvio-marine bed; the Marine (including the Chillesford clay, both the blue-laminated below and the brown-laminated above); the sands and gravels which contain the *Tellina balthica* crag at Wroxham Weybourne; and the Glacial series, which, as it does not enter into the present inquiry, I have not particularized.

The Forest-bed at Kessingland and the adjoining parish of Pake-

field is one of the richest depôts of Elephantine and Cervine remains, and also of the *Rhinoceros etruscus* *; and, judging from its position on the same horizon, and from its mineral and fossil contents, it can scarcely be doubted that it is an extension or continuation of the Bacton and Mundesley Forest-bed.

The Chillesford clay here and in a gorge between Kessingland and Pakefield, a few yards inland, is well developed. As Mr. Prestwich admits the presence of the Chillesford clay at Kessingland, and the Forest-bed is to be seen there on the beach beneath it, it is unnecessary for me to add more in support of my statement; but I am desirous to submit to the Geological Society some observations and suggestions with respect to the real position of the Forest-bed.

In order to ascertain the true position of the Forest-bed, it is requisite to have an insight into its very complex nature. The soil of the Forest-bed appears to consist of an argillaceous sand and gravel, or a compound of both, and to have been deposited in an estuary. Bones of *Elephas meridionalis*, together with a great variety of deer and other mammals, sharply fractured, but not rolled, are found in it, especially in the gravel, which is called the "Elephant-bed" on that account. These are associated with the bones of whales and fragments of wood, indicating that the estuary was open to the sea, most probably northwards, for the admission of the whales; while it appears to have been closed at the Straits of Dover and Calais, to afford a passage for the mammals into this country.

This deposit of the soil may be regarded as the first phase of the Forest-bed; and here, we may observe, a long interval may have intervened between this and the second phase, which dates from the raising of the soil to the surface of the waters and the growth of the forest upon it. In this the remains of the *E. antiquus* are most abundant; other varieties of the elephant are found here, which it is unnecessary for the subject of the present inquiry to particularize, together with *Rhinoceros etruscus* and *Trogontherium Cuvieri*. This may be regarded as the true Forest-bed; the stools of the trees belonging to it are visible along the coast at various places from Kessingland to Cromer.

The third phase commences with the gradual going down and submergence of the Forest-bed on the gathering of waters upon it. First freshwater, then fluvio-marine, and lastly marine beds (including the Chillesford clay) were successively deposited, and contain their respective faunas. A fourth phase might be added, which consists in the continuance of the undulating ridges of the Forest-bed above water after the deposit of the freshwater and fluvio-marine beds. This may be observed at Kessingland and Happisburgh. At the latter place the bones of a goat, or some ovine animal, were found, together with hazel-nuts†.

* A specimen described by Mr. Boyd Dawkins (Proceedings of the Geological Society, Jan. 8, 1868) was obtained at Pakefield.

† A fuller description was given in a paper entitled 'The Anglo-Belgian Basin,' read at the Meeting of the British Association at Nottingham.

From this brief description it is obvious that the term "Forest-bed" is inadequate to express so varied a formation, which, judging by its changes of level and of its fauna, must have continued a very long time; and I beg to suggest that the "Forest-bed series" would be a better name. The want of proper divisions has led to many complications, especially in the palæontological department.

It might be supposed that it would be easy to ascertain the position of a bed of such duration and extent; but such is far from being the case. It has a nearly uniform horizon on the level of the water, and every attempt to reach the bottom of it has been foiled by the water rising.

It is evident that it must lie between the Chalk, or London clay, below and the Chillesford clay above. In the inland section the only two intervening beds are the supposed Mammaliferous crag of Mr. Charlesworth and the Marine crag, which may be seen to advantage at Bramerton and Thorpe. Between these two beds there does not appear to be any break for the intercalation of the Forest-bed series; for they are deposited in succession upon each other in increasingly deeper water. The Mammaliferous crag was supposed to contain the *Mastodon arvernensis*, and has therefore been regarded as older than the Forest-bed, which has not been known to yield the Mastodon. Where, then, can the Forest-bed be placed in the inland section, either in point of time or of superposition?

I beg to suggest the following solution. All the specimens of *Mastodon arvernensis*, so far as I can ascertain, have been found, together with *Elephas meridionalis* and several species of *Cervus*, in a stony bed, one or two feet thick, between the surface of the chalk and the Fluvio-marine and Marine Crags; and, consequently, those crags, with the exception of a few water-worn fragments and the teeth of *Arvicolæ*, are nearly non-mammaliferous. It seems probable, therefore, that *here* may be a break for the intercalation of the Forest-bed, and that the Fluvio-marine and Marine Crags ought to be detached from this stony bed, with which they have hitherto been incorporated under the name of Mammaliferous crag. The stones appear to be derived from the disintegrated chalk, which is worn down both by the chemical and mechanical action of water.

Reference to the accompanying diagram (p. 554) may make this more intelligible. The chalk presents an inclined plane, upon which the beds from the London clay upwards have been deposited in succession. It is evident, therefore, that the chalk (or portions of it) was subaërial until covered by each successive deposit, viz.—

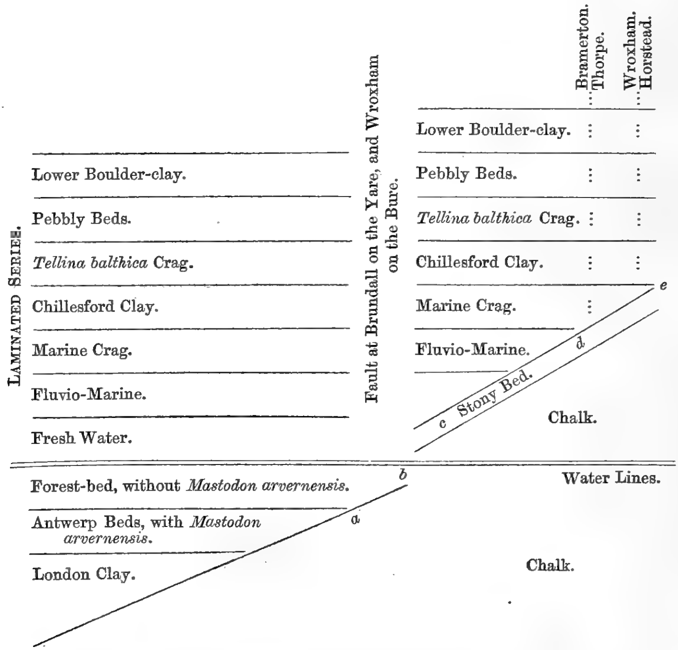
From *a*, after the Antwerp crag.
" *b*, " Forest-bed.
" *c*, " Freshwater bed.
" *d*, " Fluvio-marine.
" *e*, " Marine.

Thus there was left a land surface upon the chalk from time to time, on which the mammals of successive periods may have lived. Consequently *Mastodon arvernensis* might have lived and died upon that

portion of its surface which was afterwards occupied by the Fluvio-marine and the Marine crags; and the beds are placed in such close proximity that, notwithstanding the long period of time that may have intervened, it is difficult to separate them, especially as the crag-shells are laid upon and mingled with the stony bed.

Coast Section. *Inland Section.*

Mundesley, 20 *miles to*.............. *Norwich.*
Bacton, 18 *do.* .... *do.*



The highly mineralized and decayed condition of the bones and teeth indicates long exposure to the atmosphere; and, together with the disintegration and wearing down of the chalk by pluvial and atmospheric action, may account for their not being found in the upper part of the chalk hills. An act of justice may still be done to the memory of the illustrious Cuvier, who expressed his utter incredulity when the Mastodon's tooth found at Whittingham, near Norwich, by the father of English geology, was shown to him, and he was assured that it came from the Norwich crag. He affirmed that it was next to impossible; and the result of the above observations tends to prove that Cuvier was correct in his opinion that the Mastodon belonged to an older deposit.

A break is here established between the stony bed which contains the Mastodon and the Fluvio-marine which contains no

proboscidean remains, and an opening is made for the Forest-bed between them.

It might be supposed to be easy to trace the Fluvio-marine Crag to the coast-section, and so to prove whether it dips beneath the Forest-bed or whether it overlies it and is identical with the Fluvio-marine of the coast-section; but much difficulty arises from the Fluvio-marine crag inland being cut off and intercepted by the valleys of the Bure and of the Wensum, and several of their tributaries: and this difficulty appears to be increased by a slight upheaval of the chalk to the west of those rivers. This may be seen by the elevation of the Chillesford clay at Bramerton about 15 feet above its level at the Brundall Station; and the same may be noticed at Horstead and Wroxham, on the west side of the Bure, and at Hoveton St. John, on the east side.

On full consideration, I am inclined to the opinion that the Fluvio-marine and the Marine crags of the inland section are identical with those on the coast. The freshwater beds in the coast-section, which are absent inland, impress me with the correctness of this view of the case, because they seem to have been laid down at a lower level on the first going down of the Forest-bed; and then, when the level was obtained, the Fluvio-marine beds were spread over the freshwater beds and over the extended area of the chalk, which was covered with the bed of stones; and then, in like manner, the Marine beds were laid down, including the Chillesford clay, which is admitted to be the same in both sections.

The correspondence and junction of the several beds at both extremities of the Forest-bed are almost conclusive in favour of their identity.

On the other hand, the greater variety and quantity of mollusks in the Fluvio-marine and Marine crags of the inland sections may be regarded as evidence against their identity; but such an accumulation of shells may be expected near the strike of the beds, where the water was more shallow than at a distance from the margin of the chalk *.

I trust that the above observations respecting the stony bed upon the chalk, if not conclusive, may prove of service in determining the relative ages and positions of the Forest- and other beds.

Discussion.

Sir Charles Lyell considered the Forest-bed to be newer than the stony bed.

Mr. Gunn remarked that at Easton Bavent the Chillesford Clay is in the cliff, and the Forest-bed in the beach beneath it. He referred to various instances of the occurrence of mammalian remains on the coast beneath the Chillesford Clay, whereas he had never found any above it.

* A fresh complication has arisen from the discovery of the *Tellina balthica* in great abundance near Sherringham, beneath the Chillesford clay, and as low as the stony bed; but the introduction of these shells may be attributed to northerly currents of water.

3. *On a new* Labyrinthodont Amphibian *from the* Magnesian Limestone *of* Midderidge, Durham. By Albany Hancock, Esq., F.L.S., and Richard Howse, Esq.

(Communicated by Prof. Huxley, F.R.S., F.G.S.)

[Plate XXXVIII.]

Among the important additions to the fauna of the Permian rocks of Durham made by Joseph Duff, Esq., last autumn, not the least interesting, perhaps, may be reckoned the remains of a Labyrinthodont having numerous finely striated, rhombiform scutes or scales, resembling in shape those of some Ganoid fishes, though very superior in size. These remains were found at the Midderidge quarry (a portion of which has recently been removed for the purpose of widening the Darlington and Wear-valley Railway), in a bed of yellow marly limestone 7 or 8 feet above the marl-slate properly so called. The section at this quarry is thus described by Prof. Sedgwick, Geol. Trans. ser. ii. vol. iii. p. 76:—

"1. Bed of light-coloured siliceous sandstone, worked as a coarse flagstone and also as a building-stone. The upper beds alternate with blue-coloured calcareous shale. At East Thickley they are about 30 feet thick.

"2. Yellow-coloured calcareous shale and shale-slate, in thickness about 9 feet. Some of these beds are incoherent and sandy; the marl-slate forms a series of indurated bands, which divide the more incoherent shale.

"3. A series of thin beds with marly partings; the whole about 20 feet thick. The average thickness of the several beds is not more than a few inches; their surfaces are often covered with yellow marl; at their natural partings they are generally covered with dendritical impressions," etc.

In the above section, No. 1 represents the uppermost member of the Coal-measures, which in this part of Durham have been much disturbed and denuded prior to the deposition of the Marl-slate. It must be mentioned that in this quarry and in the south of Durham there is no bed of "yellow incoherent sand," a bed which forms an important item in the section a few miles further north and in the north of Durham generally.

The Marl-slate proper equals the lower portion of No. 2 of Prof. Sedgwick's section. When closely examined, it can be distinctly separated from the marly limestone, into which it gradually passes upwards. And it is more emphatically distinguished by the fossils it contains; for, though a few stray fishes are now and then found in the calcareous beds above, yet this lowest part is the depository for the numerous fish- and plant-remains which characterize the Permian rocks. It is, then, in the middle, or nearly so, of this yard of Marl-slate that Mr. Duff has found the remains of the *Dorypterus Hoffmanni*, Germar, and also the remains of two species of reptiles, viz. *Proterosaurus Speneri*, H. v. Meyer, and *Proterosaurus Huxleyi*, nov. spec., descriptions of which have been communicated to the Geological Society. Associated with these occurred numerous re-

mains of the fishes which have been so long well known, and fragments of plants, a few of which are new to England, though most of them have been described from the Kupferschiefer of Germany. The Mollusca observed by Mr. Duff consist of fragments of *Nautilus Freieslebeni*, Schloth., specimens of *Discina nitida*, Phil., *Lingula mytiloïdes*, Sow., and *Myalina Hausmanni*, Goldf. Of these shells, only a few imperfect specimens occurred. The appearances presented by the whole of the fossils entombed in this Marl-slate seem to lead to the conclusion that this deposit was formed in a very quiet estuary, into which the land reptiles and the freshwater Ganoids and the remains of coniferous plants were brought, to be intermixed with other exuviæ, such as the shells of *Nautili, Discinæ*, and *Lingulæ*, which are undoubtedly of marine origin.

The Marl-slate at this spot appears to be perfectly unconformable to the Coal-measures No. 1 of the above section. But between it and this sandstone there is an accumulation of yellow unctuous clay, about 2 feet thick, which has not the appearance of an original deposit, but appears to have been formed partly by the destruction of the lower part of the Marl-slate, and partly by the infiltration of water carrying in clayey particles through the extensive fissures which abound in the superincumbent limestone. Upwards the Marl-slate gradually passes, becoming more calcareous according to its height, into the thin-bedded compact limestone No. 3 of Prof. Sedgwick's section. It is in these transition beds, at about 7 feet above the Marl-slate proper, that our new Labyrinthodont was found. The beds of this portion are much thicker than in the compact limestone above, and more marly, and contain here and there small accumulations of gritty materials surrounded by hard compact limestone. The amphibian itself seems to have been imbedded in a very compact nodulous mass of one of these beds, and was fortunately brought to light by the splitting of the stone right through the central portion of the bed. In this part of the series at this quarry the only other fossil remains found were a few *Lingulæ* and fragments of a Polyzoan; but in a neighbouring quarry the beds on this horizon contain numerous remains of the well-known Permian mollusca. Although found in this higher portion of the series, we imagine there will be no difficulty in inferring that the remains of this creature were carried from its freshwater haunts to be imbedded in a deposit which was fast putting on a marine aspect.

The specimen of this new and interesting form (Pl. XXXVIII. fig. 1), for which we propose the name of *Lepidotosaurus Duffii*, is unfortunately in a bad state of preservation, owing partly to the crystalline condition of the matrix, and partly to the peculiar state of the bones, some of which look as if they were composed of dark grey carbonate of lime, while certain parts of them have a burnt appearance, and are reduced to a brittle, white, flaky, chalk-like substance, conspicuously displaying the concentric layers of growth. The fossil lies on its side, and is seen in vertical section, part of the bones being on one slab and part on the counter slab. The backbone (a, a, a') is split open longitudinally, there having been a natural division through this

part. The ribs (*e*, *e*, *e*) are divided in the same direction; but they for the most part are torn asunder, as the division has not extended much beyond the backbone. The same may be said of the head (*b*, *c*, *d*), which lies split open horizontally below the ventral margin of the animal. The neck (a') is curled round in front of the anterior end of the body in the direction of the head, which lies in a reversed position, as we have just seen, below the trunk, which to some little extent overlaps it. The tail or posterior end of the spine seems to have been turned round the hinder extremity towards the same region, but none of its bones are present; only an indistinct depression indicates the fact.

As the body lies thus curled up, it measures 15 inches in length; and in width, from the backbone to the distal extremity of the ribs, 8 inches. The length of the specimen, including the head if stretched out, would be about 35 inches.

The course of the backbone is obvious enough, running along the dorsal margin, turning round in front of the body, and curving backwards in the direction of the occipital region of the skull; but, unfortunately, at this point the slab is broken away for upwards of 2 inches, separating by that space the head from the spine. The vertebral column (*a*), as seen in longitudinal section, is about an inch and one-eighth wide; but it is quite impossible to make out any of the characters of the vertebræ, or even to determine their dimensions with the necessary precision. All that can be said on this point is that, from the assumed extent of four consecutive vertebræ, the length of a single vertebra may be estimated at about seven-eighths of an inch. This difficulty arises partly from the crystalline condition of the whole line of the vertebræ, and partly from the fact that the whole of the bone is broken up and partially removed, little else than cellular or flaky matter remaining, all boundaries determining the forms of the parts having disappeared.

There is, however, one feature of the vertebral column which cannot pass unnoticed. The neck (a') seems to have been remarkably long for a Labyrinthodont. From the length of the ribs, the body must undoubtedly have been of considerable depth; and unless the neck had been long, it is evident that the head, if attached to the trunk, as it appears to have been when deposited, could not have assumed the position in which it is placed immediately below and parallel to the belly. But it is impossible to determine the exact length of this portion of the column, as we cannot be sure how many of the anterior ribs are wanting.

The ribs (*e*, *e*, *e*) are arranged in regular order, inclining from before backwards; but have been apparently torn bodily from their spinal attachment by pressure after deposition, and now their proximal extremities are removed about an inch and a quarter from the column, the whole having been afterwards pushed downwards. Twenty-one are distinctly displayed in parallel order, about a quarter of an inch apart from each other in front; but the space dividing the posterior ones is somewhat greater. They are inclined diagonally from the front in slightly arched curves, the concavity being forward; and traces of eight or ten more can be determined, so that in all there

have been about thirty ribs. In front, too, there are indistinct impressions of one or two more; but whether or not these terminate the series in this direction, it is impossible to say.

The largest ribs, which are near the centre, are $6\frac{1}{4}$ inches in length, following the curve, and the shaft is one quarter of an inch thick; they taper slightly towards the distal extremity, and do not exhibit the longitudinal groove or depression usually observed in the ribs of Labyrinthodonts, neither are they apparently depressed in the usual manner. The proximal extremities are crushed and broken, but are widened a little, indicating a double articular surface; these extremities are, however, too imperfect to warrant any confident assertion of the fact.

The greater number of the ribs have a crystalline appearance, as if composed of a dark grey carbonate of lime; but the concentric bone-layers are for the most part conspicuously displayed. Eleven or twelve of the anterior ribs have more than an inch of their distal extremity broken away, and the ruptured ends are united to an irregular, narrow, thin, longitudinal belt of bone (*f*), which is in the same crystalline condition as the ribs, and which has a fanciful resemblance to a fragmentary breast-bone; but this appearance is altogether illusory, for, though this long belt is completely incorporated with the extremities of the ribs, the result merely of pressure, it is undoubtedly composed of the remains of a few of the dermal scales to be afterwards described.

The limbs are not present, nor can any trace of them be observed. There is, however, a thickish mass of bony matter in the dorsal region in front (*g*, *g*), lying incorporated with the proximal extremities of eight or nine of the anterior ribs, and extending in advance of them nearly as far as the curved line of the cervical vertebræ. This may, perhaps, be the remains of the scapulæ and other members of the shoulder-girdle; but the forms of the parts are entirely obliterated; indeed there is no indication of the mass having been composed of distinct parts. The thickness of the bone, which, however, cannot be easily accounted for in any other way, justifies the above supposition; and in fact, from its extent, measuring as it does 5 inches long and nearly 2 inches wide, the fair inference would seem to be that the fore limbs must have been largely developed.

There is, however, another explanation which has been suggested, which, though possible, can scarcely be considered probable: it is that this bony mass may be the remains of the large pectoral plates found in all Labyrinthodonts, which in some way or other have been removed thus far from their natural position. But this bony mass lies united to the ribs, and is covered by the dermal scales already alluded to, which appear to be undisturbed. This could scarcely be the case did this bony mass originate in the transported pectoral plates.

Further back, incorporated with the dorsal extremities of the ribs there situated, is another considerable accumulation of bony matter (*h*) in the form of a very irregular elongated belt. The greater portion of this is undoubtedly derived from the surface-scales and

the crushed ribs. At the anterior part of the belt, however, the bony substance is too thick to be thus accounted for, and, had it been placed sufficiently far backwards, it might have been supposed to be the remains of the pelvic girdle; but we fear its nature must be left undetermined.

The head, we have already observed, is seen in section, lying in a reversed position below the ventral margin, which to a limited extent overlies it, the muzzle being directed backwards (*c*, *b*, *d*). The coronal portion is on the slab on which the right side of the trunk rests; the lower or basal portion and muzzle are on the other, which may be denominated the left slab, as it contains the left side of the trunk.

The cavity of the cranium was filled with crystallized carbonate of lime, and the bone is in a very flaky tender condition, having a chalky or burnt appearance; and in some places it is so much reduced as to be difficult to trace; neither the sutures of the component bones nor much of the surface character can be determined.

The entire length of the skull is $9\frac{3}{4}$ inches; but the extremity of the muzzle is wanting. The occipital region is much injured; it is wide, truncated, and angulated at the sides; it measures across $5\frac{1}{4}$ inches: for about an inch forward the skull widens a little, and then suddenly tapers for nearly an inch and three-quarters, at which point it is 3 inches wide; here the muzzle seems to commence, and from hence it tapers gradually to the broken anterior extremity, where it is a little more than an inch and a half wide.

The portion that remains of the narrow elongated muzzle is in a better state of preservation than the rest of the skull, and is 7 inches long, and measures across the centre $2\frac{1}{2}$ inches. Only a part of the upper surface was exposed; but, aided by the skilful manipulation of our friend Mr. Atthey, to whom our best thanks are due, we have been enabled to work out the features of this characteristic portion of the cranium. The matrix has been carefully removed by that gentleman from the sides, and has been dug away from beneath, so as to exhibit to some extent the palate. Thus revealed, the muzzle is seen to be much depressed, slightly convex above, with the roof of the mouth apparently flat, or only a little concave. The maxillæ, which seem to form the sides of the muzzle, are thick at the outer margins, but are quite thin above. Unfortunately, however, the roof of this portion is much injured; there is, nevertheless, a strip about half an inch wide extending the whole length of the maxilla, along the right side, and a small portion near the centre of the left maxilla, in a tolerable state of preservation. The central portion of the roof is, for the most part, deficient,—little more than the cast of it, showing the form.

The upper surface of the roof, or as much of it as remains, and the margins of the maxillæ are studded with small conical, bluntly pointed tooth-like processes, irregularly disposed, but nowhere crowded. They are largest at the outer margins of the maxillæ, where they incline outwards, and appear to diminish in length and to become erect as they pass inwards towards the middle longi-

tudinal line. They are for the most part broken down, merely tubercular scars marking their position; but near to the centre of the left maxilla they are quite perfect, and are seen projecting into the adherent matrix, having much the appearance of minute teeth. The largest are one-sixteenth of an inch in length, and are rather obtusely pointed; several of them are coated with a thin layer of transparent glass-like enamel. Their resemblance to teeth is still further shown by a large pulp-cavity and thick dentine-like walls, which have a white milky hue, and are very tender, being evidently much changed by fossilization. They are, however, apparently processes of the bone from which they project; no distinct anchylosis can be seen, and when broken away there is no depressed scar, but their bases are persistent, like rugged tubercles.

Traces of similar tooth-like processes are found much further back on the sides of the skull. The palatal surface of the muzzle, so far as it could be explored, displays no teeth, neither does the outer or alveolar margin of the maxillæ; but not much importance can be placed on these negative facts when the peculiar state of the spemen is considered. Very little can be added to what has already been said respecting the other portions of the cranium. After carefully removing the crystalline carbonate of lime from the interior of both portions of the skull, its walls are found distinctly lining the concavities in the matrix, though in places the bone is reduced to mere traces. And in one part the coronal wall has been thrust inwards, apparently by some disturbance in the matrix; and the general distortion is so extensive that little can be determined except the contour, which has been already described, and this is not by any means perfect (see Pl. XXXVIII. fig. 2). The crown seems to have been considerably elevated and arched.

Perhaps the most interesting, and certainly the best-preserved feature of our strange amphibian has yet to be noticed. As it lies, it seems to have been covered with large, minutely striated, bony, imbricated scutes or scales, which extend from end to end and from the dorsal to the ventral margin of the specimen. These scales are arranged in diagonal lines, sloping from behind forwards, and give to the surface of the animal a strongly ribbed appearance in the same direction. The inside view of the scales presents the same sort of ribbing as the exterior; indeed both sides of this bony armature remind the observer of the ridges and furrows of a tiled roof, only the individual scales are not distinguishable as the tiles of a roof are; the ridges and furrows alone are visible, and the junction of the rows is not perceptible. This may be partly owing to the pressure to which the fossil has been subjected, incorporating the bony scales with each other; but it undoubtedly results in a great measure from the character of the scales themselves, which permit the most close and accurate fitting. However this may be, the specimen at present has the appearance of having been incased in a continuous bony shield coextensive with the trunk. No portion of the tail existing, it is impossible to say whether or not the scales extended to it.

Such is the general character of this peculiar scaly armature. Not much, however, of the external surface is seen; but a portion of two or three rows of the scales is well displayed at the anterior extremity of the ribs on the right slab, or that on which the coronal portion of the cranium is preserved. This patch of the scaly covering of course belongs really to the left side of the animal; it overlies the ribs, and in part covers the bony mass, which we suppose may be the remains of the shoulder-girdle. Other two considerable patches are observed overlying the ribs near the centre of the body, and several smaller patches are scattered over the specimen. All these patches exhibit the minute striation of the surface, and that in front displays also the ribbed structure; and the casts of all of them can be traced on the left slab. That of the anterior patch is well marked, and is of considerable extent, showing both the ridges and the minute striation of the surface.

Upon the left slab, too, the under surface of the scales is well seen, particularly a belt of a portion of four or five rows about an inch wide, that stretches along by the side of the vertebral column. And towards the posterior extremity of the specimen, the rows of scales are seen in their whole length (*i, i*) extending in parallel order from the ventral to the dorsal margin, sloping forwards, and crossed by the ribs which incline in the opposite direction. The inside of the rows of the scales is equally well displayed on the right slab.

The scales themselves (fig. 3) are rhombiform, with the angles slightly rounded, and having projecting from the lower anterior angle a strong, pointed conical process, which is overlapped by the dorsal margin of the scale next below. They are transversely elongated, and measure in this direction an inch and three-quarters, lengthwise, or from the anterior to the posterior margin, five-eighths of an inch. We shall, however, merely for the sake of convenience, consider the long measurement as that of the length, the short as that of the width.

The ends, then, of the scales are truncated diagonally from above downwards and backwards; they (the scutes) are rather stout, but gradually thin out to the margins, which are very fine, and have a widish, thick ridge extending the whole length, much nearer to the front than the posterior margin, and parallel to it. This ridge is smooth and rounded below, where it is seen to be continued into the projecting process; above, on the outer surface, it forms an obtuse ridge the entire length of the scale. The anterior part of the outer surface is smooth as far back as this ridge, and is bevelled or sloped to the margin; the posterior portion is twice as wide as the smooth anterior border, and slopes or inclines in the opposite direction or backwards, so that the longitudinal carina is like the ridge of a very low-pitched roof with one of the slopes much shorter than the other. The wide posterior slope is minutely and closely striated, the striæ being raised, sharply defined, and slightly diagonal from above downwards and backwards, and are somewhat broken and tortuous.

The scales imbricate backwards, the anterior overlapping the

posterior as far as the longitudinal ridge, so that the whole of the smooth anterior border is covered, as well as the conical process projecting from the lower extremity; and the striæ of the surface become continuous from scale to scale, and in this way the whole of the scaly surface is covered with uninterrupted striæ. This is all the more perfect as the boundaries of the scales are not distinguishable, as already stated, the thin margins overlapping with great accuracy, and the pressure during fossilization undoubtedly aiding in obliterating the visibility of the junctions. The ridges and furrows formed by the rows of scales, and the striation of the surface, alone give evidence of the presence of this scaly armature; and had it not been for the aid of some isolated scales on the margin of the specimen, their form and character could not have been determined.

From the above description, the close resemblance of the scales to those of some ganoid fishes is sufficiently obvious; indeed they might very readily be mistaken for the scales of a gigantic *Platysomus*, the chief distinguishing feature being that there is no notch to receive the peg of the adjoining scale, the connexion being merely that of superposition.

Such are the characters of this curious Labyrinthodont, as they are determinable in our specimen, and they are certainly very anomalous. The most remarkable feature is the covering of uniform fish-like scales, which undoubtedly seem to clothe the entire body from back to belly; and were this really the natural condition of the creature, it would indeed be extremely abnormal, and we should be at a loss to ascertain its affinities, particularly as very little aid is supplied by the few other characters that we have been able to make out. Is it possible, then, in any way to account for this extraordinary appearance, so as to bring *Lepidotosaurus* into the category of the Labyrinthodonts? for it seems to have some relationship to that group, as is shown by certain cranial characters to be shortly referred to.

We are indebted to the kindness of Prof. Huxley for an answer to this question. After carefully examining the specimen, and considering it in every possible way, that gentleman suggested to us that, after all, the scales that now seem to be coextensive with the whole body may be nothing more than the ventral scutes common to all Labyrinthodonts, though somewhat modified in character and more extensively developed than usual.

The specimen, as we have already pointed out, lies on its side. Now these Amphibians have had depressed bodies; and as it may be supposed that the ventral scales would be developed in proportion to the degree of depression (or, in other words, those individuals with broad bellies would have more scutes than those with narrow bellies) it is easy to see that in *Lepidotosaurus* the scutes or scales, assuming the depression to have been extreme in this form, might have been more than usually developed. It is quite possible then, nay, even likely, that on the collapse of the ventral scales, under the influence of lateral pressure, the animal lying on its side, their

outer or upper margins of both flanks might reach to the dorsal region, covering up and enclosing the ribs, exactly as is the case with the specimen before us. The perfect imbrication and close interlocking of the scales would undoubtedly conduce to this end by maintaining their compact order.

This seems to us so natural an explanation of the phenomenon, that we gladly adopt it; and thus we find the greatest difficulty of the problem turned and conquered. We are also indebted to the liberality of Prof. Huxley for pointing out to us the affinity of our new form to *Dasyceps*, also a Permian Labyrinthodont.

The relationship to the latter is seen in the form and ornamentation of the head. In *Dasyceps* the muzzle is not by any means so much produced as it is in *Lepidotosaurus*; the form, however, of the occipital region presents considerable resemblance. But what is most remarkable is that the surface of the skull is covered with minute, sharp, tooth-like processes, quite similar to those before described on the muzzle and sides of the skull of our new form.

The Bradford fossil recently described by Prof. Huxley in the Quart. Journ. Geol. Soc. vol. xxv. p. 309, under the name of *Pholiderpeton scutigerum*, shows some relationship to *Lepidotosaurus* in the large development of the ventral scutes; but they differ greatly in character from those of the latter.

The extraordinary characters of the scales, their vast development, peculiar ornamentation, and perfect mode of imbrication, as well as the greatly elongated, narrow muzzle, and other characters of the head, make it necessary to establish a new genus for the reception of the Midderidge Labyrinthodont, to which, as previously stated, we have given the name of *Lepidotosaurus Duffii*, the specific name being in honour of the gentleman who has added so much to our knowledge of the vertebrata of the British Permian rocks.

EXPLANATION OF PLATE XXXVIII.

Fig. 1. Slab exhibiting the left side of *Lepidotosaurus Duffii*, two-thirds natural size:—*a*, *a*, *a'*, line of the vertebral column; *a'*, the cervical portion of ditto; *b*, the inferior portion of the skull; *c*, small piece of the upper wall of ditto bulged inwards; *d*, muzzle exhibiting at the sides minute conical tooth-like processes; *e*, *e*, *e*, ribs; *f*, belt of bony matter, resembling a fragmentary breast-bone; *g*, *g*, anterior mass of bony matter, supposed to be the remains of the shoulder-girdle; *h*, posterior ditto, nature undetermined; *i*, *i*, inside view of the rows of dermal scales; *j*, the dorsal extremities of four or five of ditto; *k*, impressions of the anterior or lower extremities of four or five rows of scutes of the right side, showing the ridges and furrows and the minute striation of the surface; *l*, *l*, patches showing the striated impressions of scales.

Fig. 2. Outline of cranium, dorsal view; one-third natural size.

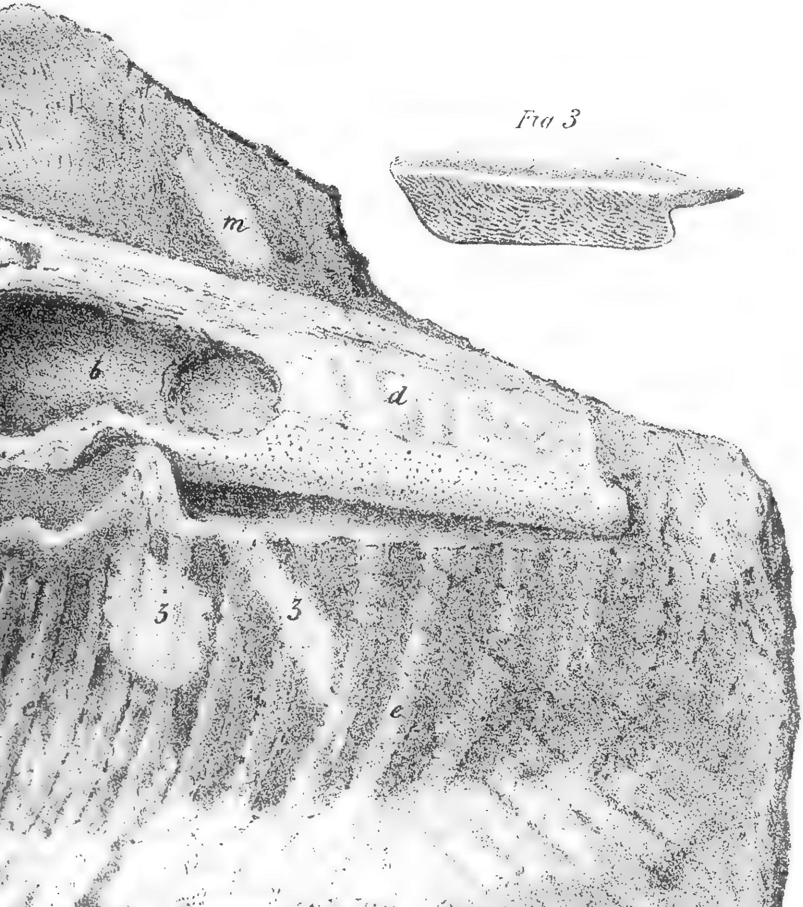
Fig. 3. A scute, about the natural size.

Fig. X $\frac{1}{3}$

Fig. I × $\frac{2}{3}$

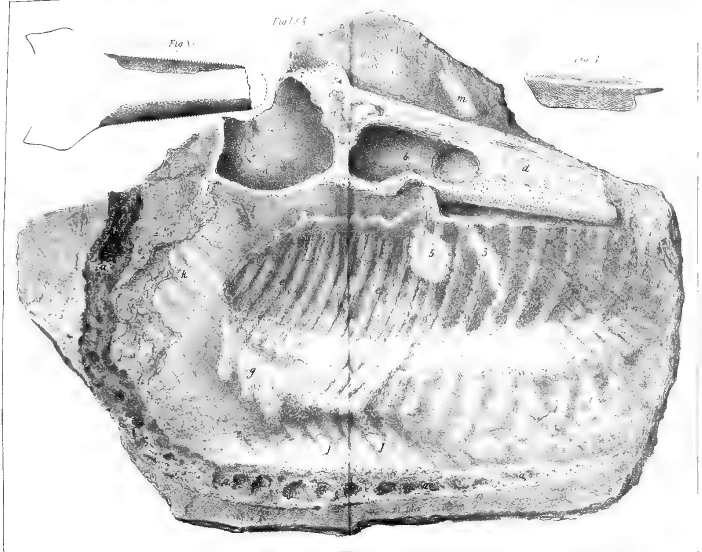
LEPIDOTOSA

Fig. 3



M. & N. Hanhart imp.

S DUFFII.



De Wilde del. et lith.

M & N Hanhart imp.

LEPIDOTOSAURUS DUFFII

4. *On* PROTEROSAURUS SPENERI, VON MEYER, *and a new species,* PROTEROSAURUS HUXLEYI, *from the* MARL-SLATE *of* MIDDERIDGE, DURHAM. By ALBANY HANCOCK, Esq., F.L.S., *and* RICHARD HOWSE, Esq.

(Communicated by Prof. Huxley, F.R.S., F.G.S.)

(PLATES XXXIX. & XL.)

IN the preceding paper it has been stated that the requirements of a railway company for increased accommodation of their traffic, and the continuous indefatigable exertions of our friend Joseph Duff, Esq., to enlarge the knowledge of the Marl-slate fauna of Durham, have led to the discovery of some fossil remains which are certainly the most interesting palæontologically of recent acquisitions. These consist of a considerable portion of the skeleton of that earliest-recorded and still oldest-known reptile, *Proterosaurus Speneri*, v. Meyer, and also in close association with it of the greater portion of the skeleton of a smaller species, for which we propose the name *Proterosaurus Huxleyi*. Through the obliging kindness of Mr. Duff these specimens have not only been placed in our hands for description, but have also been added to the collection of the Natural-History Society of Newcastle, Durham, and Northumberland.

Perhaps we may be allowed to reflect that in England we have now arrived, after the lapse of more than a century and a half, at the same point of palæontological discovery, bathymetrically considered, which was attained in Germany in the year 1706 through the intelligent observations of a learned physician of Berlin, whose name has been properly attached to this earliest discovered reptile; and also to consider this fact, that after the expiration of 164 years, and notwithstanding the exertions and multiplication of observers and enlarged fields of inquiry, these reptilian remains, described by Spener and compared by him to the Crocodile and Lizard, still continue to be the highest organisms up to this time recorded from the palæozoic rocks. And thus this discovery, though it increases our knowledge of the geographical distribution of ancient reptiles, adds nothing to our knowledge of their bathymetrical range, if we admit, as is generally done, that the English marl-slate was contemporaneous with, or deposited about the same geological period as, the German Kupferschiefer.

For the history and description of more complete specimens we must refer to the classical monograph of Hermann von Meyer, 'Fauna der Vorwelt—Saurier aus dem Kupferschiefer der Zechstein-formation.'

The geological position in which these reptiles were found has already been described in a former communication, so that it is unnecessary to repeat it here, further than to state that they were associated in the marl-slate proper on the same stratigraphical horizon with such fishes as *Platysomus*, *Palæoniscus*, &c.

The two specimens which we are about to describe were much obscured in the matrix; but by the skilful aid of Mr. Thomas Atthey the whole of the bones have been perfectly developed at the

expense of much labour and judgment. One is the remains of a well-developed individual; but little more than vertebræ and a few of the ribs in a more or less dilapidated state are preserved; but on another slab three or four perfect ribs have occurred. The other specimen is in a much more perfect condition, the principal bones of three of the limbs being well displayed as well as one of the fore feet and most of the ribs, which lie in regular order on either side of the vertebral column. The former, as already mentioned, is undoubtedly the remains of *Proterosaurus Speneri*, and the latter a new species of the same genus, *Proterosaurus Huxleyi*.

PROTEROSAURUS SPENERI, v. Meyer. (Pl. XXXIX.)

The bones of the specimen of this species are in a very perfect condition, the surface of them being quite intact, and in places having even a semigloss. The vertebræ are lying articulated in a much curved line, the animal having apparently died with the spine arched violently backwards, as seems to have been the case with all the examples hitherto obtained. In our specimen the curve is even more sharp than usual, the remains of the column forming almost half a circle. The anterior portion of it is thrown suddenly back, and at the pelvic region it is as suddenly bent upwards.

In all there are thirty-five or thirty-six vertebræ and casts of vertebræ in continuous order, measuring, if placed in a right line, 22 inches in length. Of these vertebræ twenty-one appear to belong to the trunk, and fifteen or sixteen are caudal. Now if we deduct two or three for the lumbar vertebræ, there will remain seventeen or eighteen dorsal vertebræ. Meyer concluded, after carefully enumerating the joints in all the known individuals, that the number is "not under sixteen, and not over nineteen;" so that it would appear that the whole of the dorsal vertebræ are present, in front only the cervical being deficient. As Meyer estimates the tail-joints at more than thirty-six or thirty-eight, it would then appear that more than half of them are wanting in the specimen before us.

The centrum of the dorsal vertebræ is upwards of $\frac{3}{4}$ inch long, and about $\frac{1}{2}$ inch in height. In one of the largest specimens figured by von Meyer (tab. ix.) it is $\frac{7}{8}$ inch long and $\frac{1}{2}$ inch high. It would therefore seem that the Midderidge example is full-grown and a large individual. It is impossible to observe the ends of the vertebræ, as they are all articulated; but from the appearance of the joints where they gape a little, it would seem that both the anterior and posterior articular surfaces are slightly concave, and their margins appear as if reflected; the sides of the centrum are smooth and are a little concave.

The spinous process is $1\frac{1}{4}$ inch high, being more than twice the height of the centrum, and it is $\frac{1}{2}$ an inch from back to front; consequently it is considerably shorter than the body. It is much compressed, and is expanded a little above in the direction of the long axis of the vertebræ; and the dorsal margin or crest is slightly arched in the same direction, and exhibits on the sides delicate

longitudinal radiating striæ. The upper extremity of some of the anterior spinous processes are strongly roughened at the sides, as if for muscular attachment.

The anterior zygapophyses are stout and well produced; they incline outwards and upwards. The posterior pair are considerably shorter than the anterior, and stretch backwards or outwards to overlap them.

The transverse processes are not well preserved; but distinct traces of them are observed in most of the vertebræ, and on one or two the form is pretty well seen. They are simple, short, and obtuse, and are lengthened a little in the direction of the long axis of the centrum.

The caudal vertebræ are longer in proportion to their height than those of the trunk; and the neural arch, as in them, is completely united to the body, no suture or other trace of the junction of the parts being perceptible. The spinous process is as long proportionately, and those near the root of the tail are of the same shape as those of the trunk. But further down they become considerably contracted at the base in the direction of the long axis, and gradually widen in the same place upwards. The spine of the last joint on the slab, being the fifteenth or sixteenth of the tail, exhibits at the upper margin an indication of the peculiar bifurcation of the lower distal caudal spines of this saurian.

The anterior zygapophyses are considerably longer than those of the trunk-vertebræ, and are more inclined upwards. Immediately beneath the neural arch on either side of the centrum there is a longitudinal ridge, which, near the centre of the body, is produced a little into a short projecting tubercle, the transverse process. The chevron bones forming the hæmal arch are about as long as the dorsal spine, but are much narrower, and are of a spatulate form, being narrower at the proximal and flat and small towards the outer extremity. They are not fixed, like the processes, in connexion with the neural arch, but are articulated below to the broad reflected margin of the posterior extremity of the body, articulated, as it were, between the joints, and are inclined backwards. Only a few of them remain, but two or three are well displayed on a fragment of the counter-slab, which has fortunately been preserved.

The lumbar vertebræ are not well marked, and in this region the specimen is unluckily fractured. Certainly two, perhaps three, of the last vertebræ of the trunk are, however, apparently anchylosed. Von Meyer seems to have been uncertain whether there were two or three pelvic joints; but from what he states it would seem likely that three is the number.

A fragment of a flattened rounded bone, measuring $1\frac{1}{8}$ inch across, lies directly below the lumbar vertebræ. This is probably a portion of the pelvic girdle, and is the only indication of its presence. This resembles in form the rounded extremity of a bone (tab. iv. f. 1, 2, of von Meyer's work) lying in contact with the femur, and is probably a portion of either the pubis or ischium.

Immediately in front of the fragment lie the short ribs, which are

not more than an inch long; they are only slightly arched, with the head a little enlarged and the distal extremity obtusely pointed. Further in advance there are the remains of three or four other ribs, with more or less of the enlarged proximal extremity preserved and lying on the vertebræ apparently near to the point of articulation. One such extremity, the most anterior, is pressed down upon the sixth or seventh vertebra in advance of the sacrum. It lies immediately behind and below the distorted and broken transverse process, to which it is probably attached. Portions of the other heads occupy relatively exactly the same position on the two posterior vertebræ.

The head of each rib is of a triangular form, and is compressed, with the articulating surface simple and almost straight. The shaft at the proximal extremity is rather strongly bent; it is afterwards slightly and regularly arched, and at first it is narrow and almost cylindrical, afterwards it widens and flattens, and is grooved longitudinally; the distal end is truncated for the attachment of the ventral ribs, of which, according to Meyer, there are three to each vertebral rib. The ventral ribs are not preserved in our specimen, with the exception of one or two. Two or three ribs on a portion of the counter-slab measure $4\frac{3}{8}$ inches in length along the chord. The widened extremity is $\frac{1}{4}$ inch broad; the constricted portion above is not more than half that width.

Proterosaurus Huxleyi, n. sp. (Pl. XL.)

The small specimen of *Proterosaurus*, though far from being perfect, is not by any means so much mutilated as the large example of the genus above described. It lies apparently on its belly, with the two anterior limbs spread out, and the principal bones of the left posterior limb lying nearly in their natural order, though dislocated. In front of the trunk the neck-joints are scattered about in contact with the right coracoid; and a little further in advance towards the left is apparently a fragment of the skull, an arched bone $\frac{5}{8}$ of an inch in length. The lumbar vertebræ are not present, and the proximal caudal vertebræ are likewise deficient, the slab being broken away at this point; but a few of the distal ones can be traced. The ribs are spread out on either side of the spinal column, which strongly marks the central line. The trunk of the body from the pelvic region, or from the point where the slab is broken away, to a point level with the supposed cranial fragment, is about 5 inches in length.

The bones are in a peculiar state. The surface of most of the limb-bones and ribs is well preserved: these bones seem to have been hollow, and are filled up with galena; but the vertebræ and some of the smaller bones, such as the carpals, are almost entirely composed of that mineral; and when this is the case, the form of the bones is often much distorted, apparently by the influence of the lead-ore in assuming its usual cubic form.

The vertebræ are not in a good state of preservation; they are much injured by the deposition of the galena, as above referred to, which has so distorted the form of the bones that it is quite impos-

sible to make out the parts, or to say whether or not they are provided with the long characteristic spinous processes of *P. Speneri*. Indeed it is difficult to determine the number of joints, though twelve can be counted. As, however, there are fourteen or fifteen pairs of ribs, there must be at least as many dorsal vertebræ. It would still seem, nevertheless, that they are not so numerous in this species as they are in *P. Speneri*, in which we have seen there are seventeen or eighteen dorsal vertebræ. But it is quite possible, indeed it is likely, that there are more ribs than we have been able to enumerate, in which case we have underestimated the number of the vertebræ; and the two species may be found to agree in this particular more closely than is apparent. It is equally impossible to ascertain the character and exact number of the cervical vertebræ; but as six or seven lie scattered about in front of the trunk, it would seem that this species may have seven, the number of the neck-vertebræ of *P. Speneri* according to Meyer. All that can be said about the caudal vertebræ is, that the traces of their remains seem to indicate that the tail, when perfect, must have been of considerable length. About 2 inches of the distal extremity is determinable; and as about the same length of the proximal portion seems to be broken away, the tail, when complete, must have been longer than the trunk, which is nearly $3\frac{1}{2}$ inches in length.

The ribs lie, as we have already said, spread out in their natural order on each side of the vertebral column, and fourteen or fifteen pairs can be enumerated; but there is some difficulty in determining the precise number. They are well and regularly arched from end to end, and are moderately and nearly equally thick throughout. Towards the proximal end they are a little flattened, and terminate in a slightly enlarged simple head of a triangular form. The distal extremity is abruptly truncated, but is not flattened and widened to the same degree as the ribs of *P. Speneri*; neither are the ribs so decidedly grooved as they are in that species, but are, on the whole, more cylindrical. The ventral ribs appear to have been numerous and comparatively stout; they lie pressed in between the vertebral ribs near to the spinal column, but their relative number cannot be ascertained. The longest vertebral ribs are near the centre of the trunk; here they are $\frac{7}{8}$ inch long, measured along the chord; they shorten a little before and behind to about $\frac{7}{10}$ inch in front and $\frac{4}{10}$ behind.

Both the coracoids are well preserved, particularly the left, which lies nearly in its natural position at the left side on the fore part of the trunk. The right coracoid is removed a short distance in front. They are stout discoidal bones $\frac{5}{8}$ inch in diameter, with a deep, wide notch, apparently on the posterior margin, forming the glenoid cavity for the articulation of the humerus. At the inner margin of the notch there is an elevated boss; and from thence to the front margin there is a widish ridge indicating perhaps the compound nature of this bone, which is most likely composed of both the coracoid and scapula, the glenoid cavity being as usual at the junction of the two elements; but there is no distinct trace of a suture. There is a

straight narrow bone lying with one end in contact with the right coracoid, which may perhaps be a clavicle. A somewhat similar bone is also in contact with the left coracoid, but in this instance it has in some respects the character of a rib.

The humerus is one inch long, and is a slightly arched stout bone, with the extremities a little expanded; the distal end, which is the wider of the two, is fully $\frac{1}{4}$ inch across, while the most constricted part of the shaft is a little more than half that width. The proportional measurements of the humerus in *P. Speneri* differ considerably from the above. In that species this bone has the extremities extremely wide. One figured by von Meyer (tab. ix.), which is $2\frac{1}{2}$ inches long, has the shaft $\frac{3}{8}$ of an inch thick, while the proximal extremity is a little less than $\frac{9}{8}$ inch wide and the distal $\frac{9}{8}$. In *P. Huxleyi* the proximal extremity is very little wider than the shaft, and the distal extremity is about twice as thick as the shaft. In *P. Speneri* the proximal and the distal extremities are three times the width of the shaft.

The radius and ulna are not by any means slender; they are about $\frac{7}{10}$ of an inch long, being considerably shorter than the humerus. The radius is not quite so stout as the ulna, and both exhibit a slight sigmoidal curve. The latter is $\frac{1}{10}$ of an inch thick at the centre of the shaft, but is a little enlarged at the extremity.

The hand, including the wrist, is a little longer than the lower arm. There are two rows of carpals, of which, though disposed in nearly regular order, it is not easy to determine the precise number. There seems, however, to be three in the proximal row, and four or five in the distal, in all seven or eight. The metacarpals are long, being not much short of the length of the toes, of which there are five. The number of joints in each will have to be estimated rather than precisely determined; for the extremities are considerably injured. The first is the shortest, and has apparently two phalanges; the second has three; the third has four, all of which are quite distinct; the fourth, which, judging from the size of the phalanges, is the longest, has four, but as no trace of the claw is present, there has no doubt been an additional joint, bringing the number up to five, and if so, agreeing in this respect with *P. Speneri*.

The left fore limb is almost as perfect as the right, and lies stretched out nearly at right angles with the trunk, with the front aspect exposed; the back of the right limb is uppermost. The proximal end lies upon the coracoid; the distal extremity is separated by a short space from the radius and ulna, both of which are extended in parallel order to unite with the projecting wrist and hand. The two latter, however, are so much injured by the accumulation of galena that the parts are much obscured.

The chief bones of the left hinder limb, though dislocated, are lying close to the pelvic margin in nearly their natural sequence. The femur is as stoutly developed as the humerus; it is $1\frac{1}{4}$ inch long, consequently a little more than $\frac{1}{8}$ of an inch larger than the upper bone of the anterior limb; it is slightly bent, and has the extremities gradually but not excessively enlarged. The shaft is $\frac{1}{8}$ of

an inch thick, and the proximal extremity is nearly double that thickness, the increase being due in part to a ridge, apparently at the outer or upper surface.

The tibia and fibula are $1\frac{1}{10}$ inch long, so that they are a little more than $\frac{1}{8}$ of an inch shorter than the femur. They are nearly straight; the fibula is slender, and does not seem to have been much enlarged at the extremities, which are, however, not perfect. The tibia is considerably stouter, but not by any means so thick as the femur. The distal end is gradually thickened a little, but the proximal extremity is considerably and rather suddenly enlarged. In this, as in all the other bones, the articular extremities, having been formed of cartilage, are wanting, the ends being truncated. It is therefore quite impossible to describe in detail the characters of the joints.

Fragments, apparently of the right tibia and fibula, and three or four of the phalanges, are scattered about in the vicinity of the bones of the left leg; but no other traces of the right limb are to be found.

The only portion of the pelvic girdle present is the extremity of a flat bone. This fragment is $\frac{3}{10}$ of an inch long, and $\frac{2}{10}$ of an inch wide; it slightly widens towards the anterior extremity, which is truncated. This is probably a portion of the ilium.

From the above description it seems evident enough that this small reptile is a true *Proterosaurus*, and that it is specifically distinct from *P. Speneri*. The long articulating limbs and extensively produced tail are common to both species. In both, too, the neck has been of considerable length, and the number of cervical vertebræ (seven) is apparently the same in both. And the number of the dorsal vertebræ would likewise appear to agree in both species, and in each there are numerous ventral ribs. The same harmony is found in the number and character of the hand-bones. Unfortunately no comparison can be instituted respecting the skulls and the individual features of the vertebræ, as these parts in the new species are too imperfectly preserved; enough, however, seems to be known to warrant the assertion that the two are generically coordinate.

It appears equally clear that the small individual is specifically distinct. The diminutive size alone suggests this, especially as there are no appearances of immaturity; and the form of the ribs would seem to prove its specific distinctness. In *P. Huxleyi* we have seen that they are flattened towards the proximal extremity, while in *P. Speneri* they are rounded at this part; and in the former they are not widened and grooved to any thing like the same degree at the distal extremity.

The limbs, too, are proportionately different. In *P. Speneri* the fore limb is $4\frac{7}{8}$ inches long, as figured in von Meyer's work, tab. ix. The hind limb is $7\frac{5}{8}$ inches in length; consequently the former is $\frac{1}{3}$ shorter than the latter. In *P. Huxleyi* the fore limb is $1\frac{7}{10}$ inch in length, the hind limb $2\frac{3}{8}$ inches long; the former in this species therefore considerably more than $\frac{2}{3}$ the length of the latter.

In the new species, then, the limbs vary more in length than they

do in the old ones, the hind limb being considerably longer in the former, in proportion to the fore limb, than is the case in *P. Speneri*.

The difference likewise is strongly marked in the proportions of the humerus. On referring to von Meyer's tab. ix., above quoted, the constricted part of the shaft of the humerus therein figured measures $\frac{3}{8}$ inch wide, while the distal extremity is $\frac{9}{8}$ inch across: thus it appears that the latter part is three times wider than the former. In *P. Huxleyi* the narrow part of the humerus is $\frac{1}{8}$ inch thick, and the distal extremity is $\frac{2}{8}$ inch wide: so here the disparity is only as two to one, but in *P. Speneri* it is as three to one. It must be stated, too, that in the old species the proximal end of the humerus is nearly as wide as the distal, while in the new species it is only slightly enlarged.

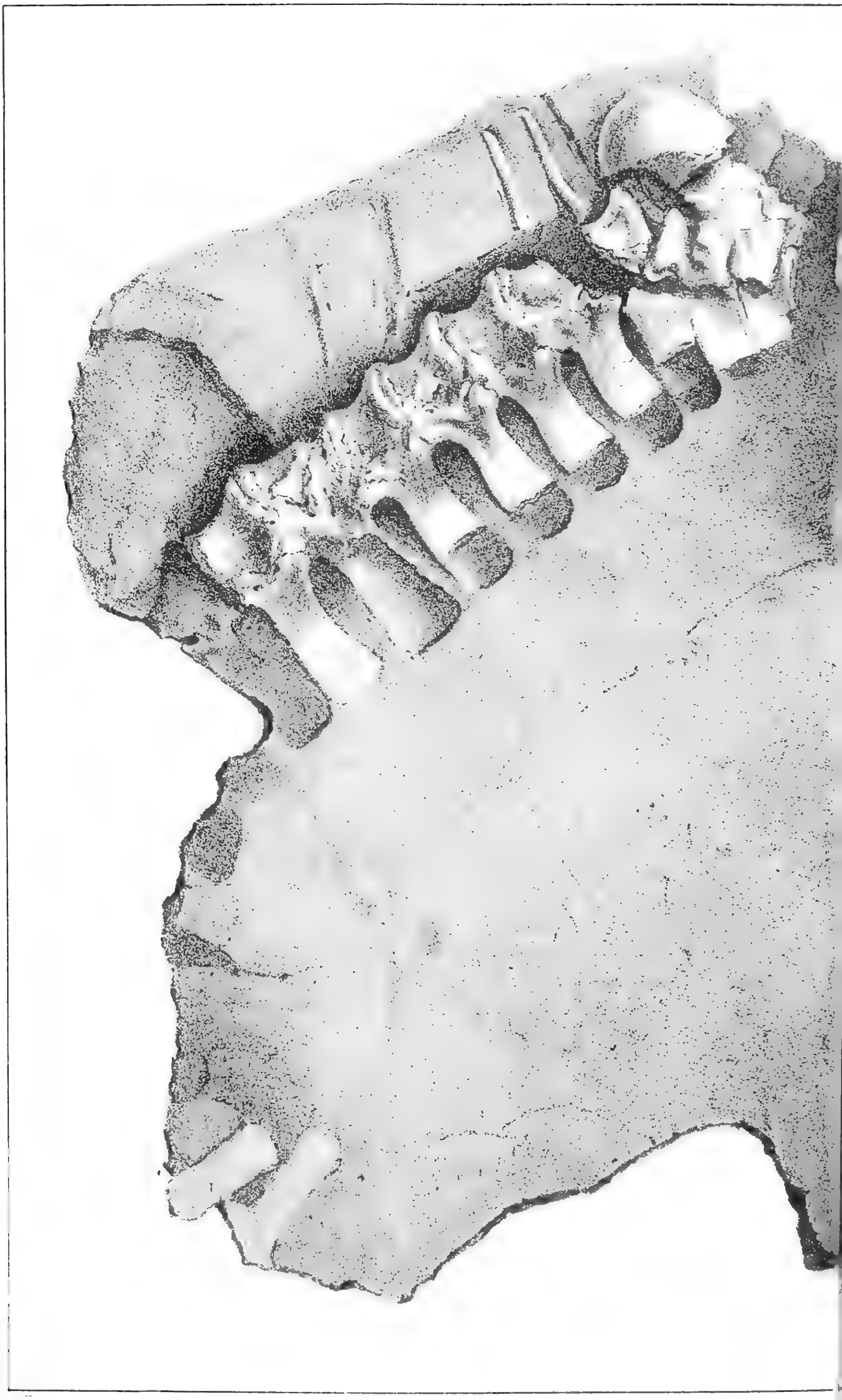
EXPLANATION OF PLATES XXXIX. & XL.

Plate XXXIX.

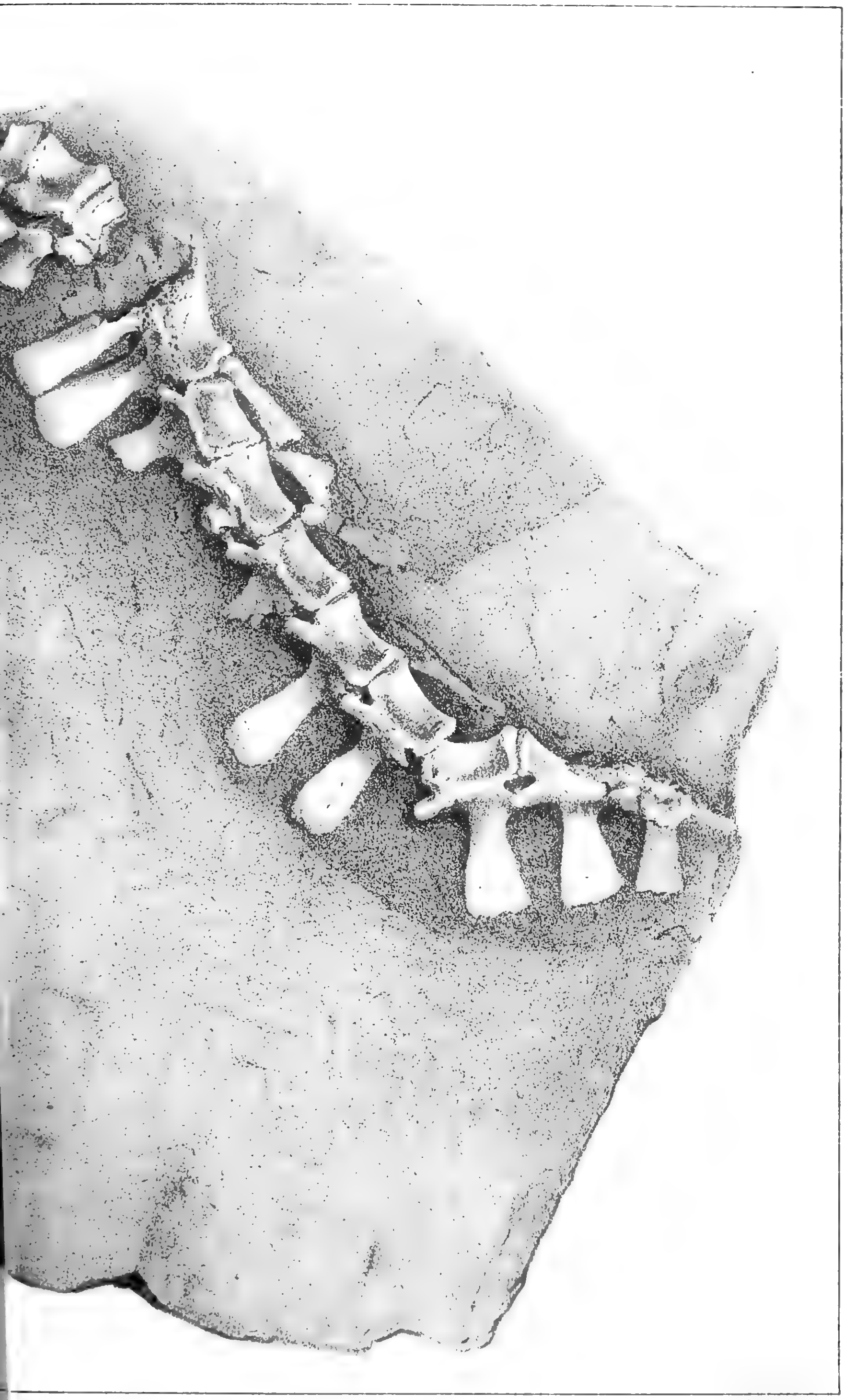
Slab of Marl-slate from Midderidge, containing the vertebral column &c. of *Proterosaurus Speneri*, von Meyer.

Plate XL.

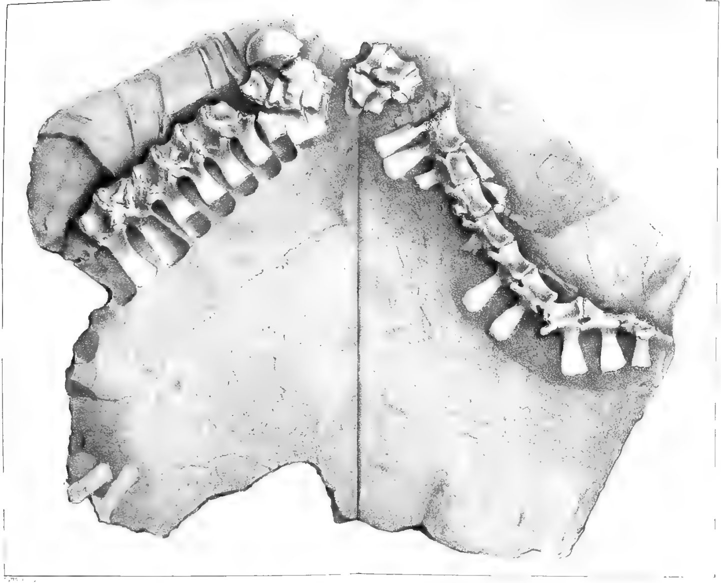
Slab of Marl-slate from Midderidge, containing the skeleton of *Proterosaurus Huxleyi*, sp. nov., Hancock and Howse.

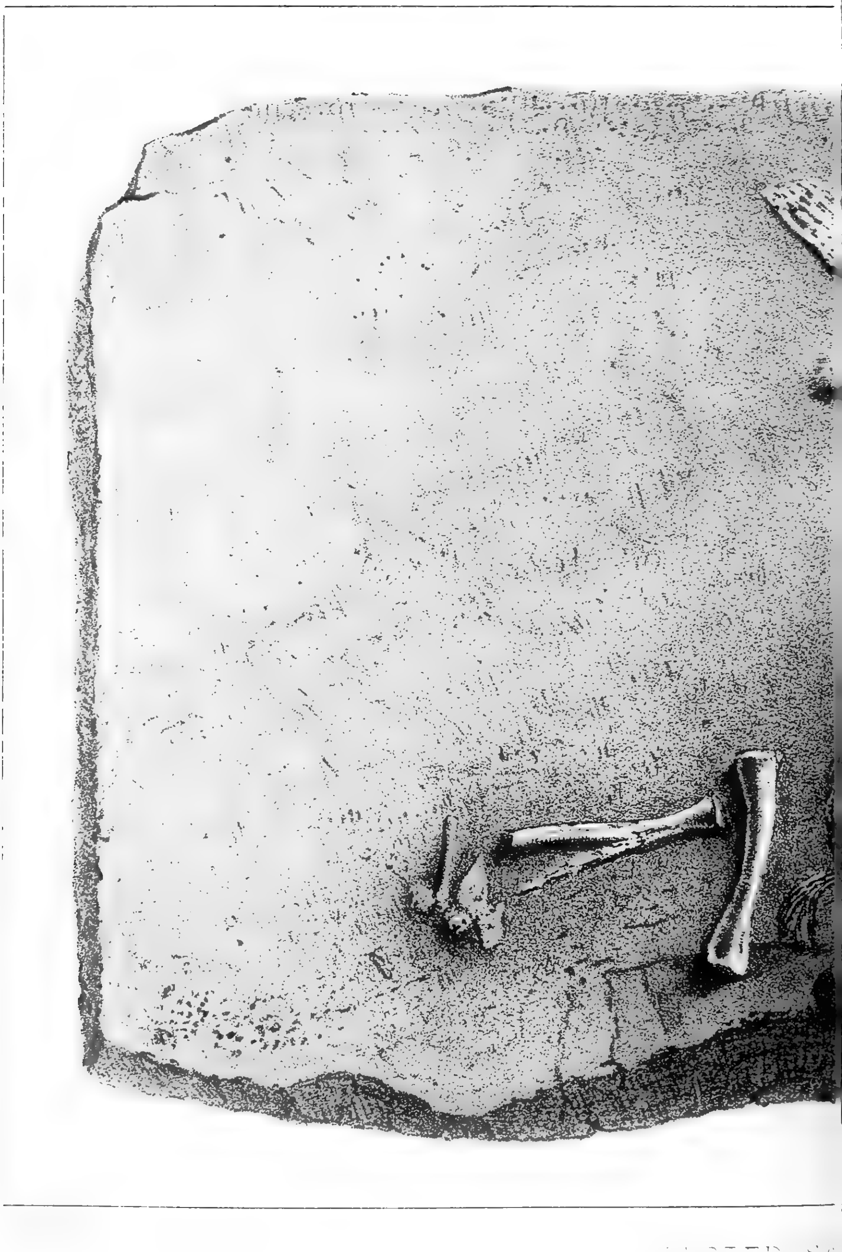


PROTEROS



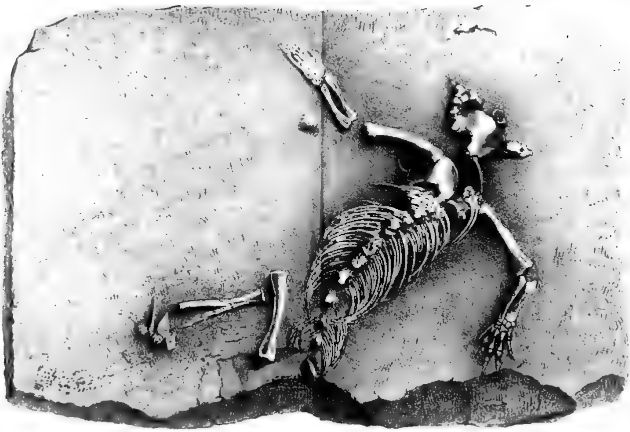
S SPENERI





M & N Hanhart imp

S HUXLEYI.



DONATIONS

TO THE

LIBRARY OF THE GEOLOGICAL SOCIETY.

From April 1st to June 30th, 1870.

I. TRANSACTIONS AND JOURNALS.

Presented by the respective Societies and Editors.

Academy (Journal). No. 7. April 1870.

American Journal of Conchology. Vol. v. Parts 1 & 2. 1869–70.

W. M. Gabb.—Description of some Secondary Fossils from the Pacific States, 5.

——. Description of new species of South-American Fossils, 25.

T. A. Conrad.—Description of Miocene, Eocene, and Cretaceous Shells, 39.

——. Description of new Fossil Mollusca, principally Cretaceous, 96.

American Journal of Science and Arts. Second Series. Vol. xlix. Nos. 146 & 147. March and May 1870.

G. H. Perkins.—Notice of a recent Land-slide on Mount Passaconaway, 158.

J. P. Kimball.—On the Silver-mines of Santa Eulalia, State of Chihuahua, Mexico, 161.

T. S. Hunt.—On Norite or Labradorite Rock, 180.

A. A. Hayes.—On the cause of the colour of the Water of Lake Leman, Geneva, 186.

O. C. Marsh.—Notice of some Fossil Birds from the Cretaceous and Tertiary Formations of the United States, 205.

J. L. Smith.—On the Franklin-County Meteoric Iron, and the presence of Cobalt and Lead in Meteoric Irons, 331.

——. Remarks on the Alkalies contained in the mineral Leucite, 335.

H. Wurtz.—Examination of a new and extraordinary Gas-well in the State of New York, 336.

H. Y. Hind.—On the Laurentian and Huronian Series in Nova Scotia and New Brunswick, 347.

American Naturalist. Vol. iv. Nos. 1–4. March to June 1870.

N. S. Shaler.—The Time of the Mammoths, 148.
J. S. Newberry.—The Surface-geology of the Basin of the Great Lakes and the Valley of the Mississippi, 193.

Athenæum (Journal). Nos. 2213–2225. April to June 1870.

J. Phillips.—*Cetiosaurus*, 454.
Canadian Iron-sand, 646.

Bath Natural-History and Antiquarian Field-club. Proceedings. Vol. ii. No. 1. 1870.

C. Moore.—The Mammalia and other Remains from Drift-deposits in the Bath Basin, 37.

Berlin. Monatsbericht der königl.-preussischen Akademie der Wissenschaften zu Berlin. January to April 1870.

C. G. Ehrenberg.—Ueber die Bacillarien-Bänke im Hochlande Californiens, 126.

——. Zeitschrift der deutschen geologischen Gesellschaft. Band xxii. Heft 1.

T. Kjerulf.—Ueber die Terrassen in Norwegen und deren Bedeutung für eine Zeitberechnung bis zur Eiszeit zurück, 1.
— Delesse.—Lithologie der Meere der alten Welt, 15.
A. Kunth.—Beiträge zur Kenntniss fossiler Korallen, 24 (1 plate).
— Runge.—Anstehende Juragesteine im Regierungsbezirk Bromberg, 44 (1 plate).
H. Abich.—Der Ararat, in genetischer Beziehung betrachtet, 69 (1 plate).
— Websky.—Ueber die chemische Constitution des Uranophans, 92.
E. Kayser.—Ueber die Contactmetamorphose der körnigen Diabase im Harz, 103.
G. Berendt.—Geologie des Kurischen Haffes und seiner Umgebung, 173.

——. Zeitschrift für die gesammten Naturwissenschaften. Vol. xxxiii. 1869.

L. Brandes.—Geologische Beschreibung der Gegend zwischen Blankenburg, Hüttenrode, Marmormühle, Bode und Thale, 1 (3 plates).

——. ——. Vol. xxxiv. 1869.

F. Mühlberg.—Beziehungen der erratischen Bildungen zur Tertiärzeit und zur Gegenwart im Aargau, 185.

Berwickshire Naturalists' Club. Proceedings. Vol. vii. No. 1. 1869.

Birmingham. The Eighth Annual Report of the Free-Libraries Committee of Birmingham.

Bordeaux. Actes de la Société Linnéenne de Bordeaux. Tome xxvi. 3e Série. Tome iv. 5e et 6e livraison. 1868–70.

V. Raulin.—Description de l'île de Crète, 353, 517.

British Association for the Advancement of Science. Report. Exeter, 1869.

W. H. Baily.—Report on the Fossils obtained at Kiltorkan Quarry, Co. Kilkenny, 73.
P. M. Duncan.—Second Report on the British Fossil Corals, 150.
J. Thomson.—Report of the Committee appointed to get cut and prepared Sections of Mountain-Limestone Corals for photographing, 171.
H. Bauerman.—Report on Ice as an Agent of Geologic Change, 171.
W. Pengelly.—Fifth Report of the Committee for exploring Kent's Cavern, Devonshire, 189.
C. Moore.—Report on Mineral Veins in Carboniferous Limestone and their Organic Contents, 360.
R. Brown.—On the Elevation and Depression of the Greenland Coast, 85.
E. A. Conwell.—On a Fossil Mussel-shell found in the Drift in Ireland, 87.
T. Davidson's Notes on the Brachiopoda hitherto obtained from the "Pebble-bed" of Budleigh-Salterton, near Exmouth in Devonshire, 88.
C. Le Neve Foster.—On the occurrence of the Mineral *Scheelite* (Tungstate of Lime) at Val Toppa Gold-mine, near Domodossola, Piedmont, 88.
R. A. C. Godwin-Austen.—On the Devonian Group considered geologically and geographically, 88.
— Hicks.—Notes on the Discovery of some Fossil Plants in the Cambrian (Upper Longmynd) Rocks, near St. David's, 90.
H. H. Howorth.—On the Extinction of the Mammoth, 90.
E. Hull.—On the Source of the Quartzose Conglomerate of the New Red Sandstone of the Central portion of England, 91.
C. Jecks.—On the Crag Formation, 91.
J. Jeffreys.—On the Action upon Earthy Minerals of Water in the form of heated Steam, urged by wood fuel, an experiment reported to the Association at its Meeting at Glasgow in 1840, 92.
J. D. La Touche.—On an Estimate of the quantity of Sedimentary Deposit in the Onny, 93.
——. On Spheroidal Structure in Silurian Rocks, 95.
J. E. Lee's Notice of remarkable Glacial Striæ lately exposed at Portmadoc, 95.
G. A. Lebour.—On the Denudation of Western Brittany, 95.
——. Notes on some Granites of Lower Brittany, 96.
J. L. Lobley.—On the Distribution of the British Fossil Lamellibranchiata, 96.
G. Maw.—On the Trappean Conglomerates of Middletown Hill, Montgomeryshire, 96.
——. On Insect-remains and Shells from the Lower Bagshot Leaf-bed of Studland Bay, Dorsetshire, 97.
L. C. Miall.—Experiments on Contortion of Mountain-Limestone, 97.
C. Moore.—On a Specimen of *Teleosaurus* from the Upper Lias, 97.
H. A. Nicholson.—On some New Forms of Graptolites, 98.
G. W. Ormerod.—Sketch of the Granite of the Northerly and Easterly sides of Dartmoor, 98.
C. W. Peach.—Notice of the Discovery of Organic Remains in the Rocks between the Nare Head and Porthalla Cove, Cornwall, 99.

British Association for the Advancement of Science. Report. Exeter, 1869 (*continued*).

W. Pengelly.—On the alleged occurrence of *Hippopotamus major* and *Machairodus latidens* in Kent's Cavern, 99.
——. Source of the Miocene Clays of Bovey Tracey, 99.
J. Randall.—Denudation of the Shropshire and South-Staffordshire Coal-fields, 100.
P. Tchihatchef.—"Paléontologie de l'Asie Mineure," 100.
J. Thomson.—On new forms of *Pteroplax* and other Carboniferous Labyrinthodonts, and other *Megalichthys*; with Notes on their Structure, by Prof. Young, 101.
——. On Teeth and Dermal Structure associated with *Ctenacanthus*, 102.
H. Woodward.—On the Occurrence of *Stylonurus* in the Cornstone of Hereford, 103.
——. On a discovery of a large Myriapod of the genus *Euphoberia* in the Coal-measures of Kilmaurs, 103.
——. Freshwater Deposits of the Valley of the River Lea in Essex, 103.

Brussels. Académie Royale des Sciences, des Lettres et des Beaux-Arts. Annuaire. 1870.

——. Bulletins de l'Académie Royale de Belgique. 2me Série. Tome xxvii. 1869.

F. L. Cornet et A. Briart.—Notice sur les dépôts qui recouvrent le calcaire carbonifère à Soignies, 11 (1 plate).

——. ——. 2me Série. Tome xxviii. 1869.

R. Malherbe.—De la présence de chlorures alcalins dans les eaux et les roches du bassin houiller de Liége, 102.
Dewalque.—Sur le terrain carbonifère de la Belgique, 249.
L. de Koninck.—Sur quelques Echinodermes remarquables des terrains paléozoïques, 544 (1 plate).
H. Nyst.—Discours sur les animaux inférieures fossiles de la province d'Anvers, 607.

——. Mémoires couronnés et autres mémoires, publiés par l'Académie Royale de Belgique. Collection in-8vo. Tome xxi. 1870.

A. Perrey.—Note sur les tremblements de terre en 1866 et 1867, avec suppléments pour les années antérieures de 1843 à 1865, 5.

——. Mémoires couronnés, et mémoires des savants étrangers, publiés par l'Académie Royale de Belgique. 4to. Tome xxxiv., 1867–70. 1870.

A. Briart et F. L. Cornet.—Description Minéralogique, Géologique et Paléontologique de la Meule de Bracquegnies.

Calcutta. Asiatic Society of Bengal. Proceedings. No. 11. December 1869.

——. ——. ——. Nos. 1–3. January to March 1870.

——. ——. Journal. New Series. Vol. xxxviii. Nos. 158 & 159. 1870.

Canadian Journal. New Series. Vol. xii. No. 5. April 1870.

J. L. Thompson.—On the Cause of the Glacier Motion, 412.

Canadian Naturalist and Quarterly Journal of Science. New Series. Vol. iv. No. 4. December 1869.

T. S. Hunt.—Volcanos and Earthquakes, 387.
E. Billings.—Notes on the Structure of the Crinoidea, Cystidea, and Blastoidea, 426.
F. B. Meek and A. H. Worthen.—Notes on some points in the Structure and Habits of the Palæozoic Crinoidea, 434.
Igelström, Nordenskiöld, and Ekmann.—On the Existence of Rocks containing Organic substances in the Fundamental Gneiss of Sweden, 452.
T. Macfarlane.—On the Geology and Silver-ore of Wood's Location, Thunder Cape, Lake Superior. Part 2, 59.
Geology and Mineralogy, 467.

Chemical News. Vol. xxi. Nos. 539–551.

Chemical Society. Journal. Second Series. Vol. viii. April and May 1870.

Colliery Guardian. Vol. xix. Nos. 482–494.

Copenhagen. Oversigt over det Kongelige danske Videnskabernes Selskabs Forhandlinger. 1868, No. 5; and 1869, No. 2.

Dresden. Sitzungs-Berichte der naturwissenschaftlichen Gesellschaft Isis zu Dresden. Jahrg. 1869. Nos. 10–12. October to December.

H. Credner.—Ueber das Massenvorkommen von gediegenem Kupfer in Nordamerika, 182.
W. Hilgard.—Ueber das Neueste in der Geologie der Südweststaaten Nordamerikas, 183.
Otto.—Die Neueren Untersuchungen auf Steinsalz in Preussen, 188.
Günther.—Einiges über in der Menschenzeit ausgestorbene Thiere, 227.
G. Jenzsch.—Einige Worte in Betreff seiner Eruptivgesteins-Organismen, 248.

East India Association. Journal. Vol. iv. No. 1. 1870.

Einsiedeln. Protokoll der geologisch-mineralogischen Sektion der Versammlung der Schweizerischen Naturforschenden Gesellschaft in Einsiedeln, den 25. August 1868.

Electric Telegraph and Railway Review. Vol. i. Nos. 11–16.

Florence. Bollettino del Reale Comitato Geologico d'Italia. Nos. 2–5. February to May 1870.

I. Cocchi.—Cenno sui terreni stratificati dell' Isola d'Elba, 39, 70.
G. Negri ed E. Spreafico.—Saggio sulla Geologia dei dintorni del Lago di Lugano, 56.
E. Bechi.—Analisi chimica della Selagite di Montecatini di Val di Cecina, 64.

Florence. Bollettino del Reale Comitato Geologico d'Italia. Nos. 2–5 (*continued*).

E. Bechi.—Analisi della roccia prenitoide di Montecatini, e della Prenite dell' Impruneta, 66.
A. Manzoni.—Della Fauna marina di due lembi miocenici dell' alta e media Italia, 80.
E. Bechi.—Analisi chimiche de alcuni minerali delle Isole del mare Toscano, 82.
G. vom Rath.—Sulle roccie eruttive dei dintorni di Campiglia nella maremma toscana, 85.
G. Theobald.—Sulla geologia dei dintorni di Bormio (Valtellina), 102.
G. Grattarola, F. Momo.—Taglio del Viale dei Colli a Firenze, 107.
L. Maggi.—Intorno al conglomerato dell' Adda, 130.
G. vom Rath.—Colli Euganei presso Padova, 132.

Geological Magazine. Vol. vii. Nos. 4–6. April to June 1870.

H. M. Jenkins.—Geology of Belgium, 149, 199 (1 plate).
T. H. Huxley.—On the Milk Dentition of *Palæotherium magnum*, 153 (1 plate).
T. R. Jones.—Notes on the Tertiary *Entomostraca* of England, 155.
S. Allport.—On the Basaltic Rocks of the Midland Coal-fields, 159.
J. E. Taylor.—Notes on the Middle-Drift beds in Cheshire, 162.
F. B. Meek.—Geology of the Line of the Great Pacific Railroad, 163.
G. Maw.—The Rhætic Beds in Shropshire, 203.
C. Lapworth.—Geology of Galashiels, 204, 279 (1 plate).
J. Croll.—The Boulder-clay of Caithness, 209, 271 (1 plate).
T. R. Jones.—The *Entomostraca* of the South-Wales Coal-field, 214 (1 plate).
J. W. Judd.—On the use of the term *Neocomian*, 220.
R. Harkness.—On the occurrence of Elephant-remains in Ireland, 253.
L. de Koninck.—On some new and remarkable Palæozoic Echinoderms, 258 (1 plate).
J. Aitken.—The Grit rocks of the North-Wales Border, 263.
T. G. Bonney.—On supposed *Pholas*-burrows in Derbyshire, 267.
W. Laidlay.—Note on a Pre-historic Dwelling and Kitchen-midden in Haddingtonshire, 270.
W. Pengelly.—'On the Submerged Forest at Blackpool, South Devon,' noticed, 164.
'Archives of the Natural-History Exploration of Bohemia,' noticed, 167.
'Mineral Wealth of India,' noticed, 167.
J. M. Crombie.—'The Alpine Flora of Britain,' noticed, 229.
'Proceedings of the Bristol Naturalists' Society,' noticed, 229.
D. Mackintosh.—'On the mode of accumulation of the Drift-deposits of the West Riding of Yorkshire,' noticed, 284.
'Memoirs of the Geological Survey of England and Wales,' reviewed, 169.
'Memoirs of the Geological Survey of India,' reviewed, 171.
'Popular Geology for the Bohemian people,' reviewed, 173.
Lartet and Christy's 'Reliquiæ Aquitanicæ,' reviewed, 174.
'Report on Ice as an Agent of Geological change,' reviewed, 175.
C. W. Gümbel's 'Fossil Foraminifera &c.,' reviewed, 178.
W. Carruthers.—'On Fossil Botany,' reviewed, 181.

Geological Magazine. Vol. vii. Nos. 4–6 (*continued*).

Pictet's 'Jurassic and Cretaceous Rocks,' reviewed, 230.
Wynne's 'Poorna Valley,' reviewed, 232.
'Transactions of the Edinburgh Geological Society,' reviewed, 233.
E. T. Stevens's 'Flint-Chips, a guide to Pre-historic Archæology,' reviewed, 286.
Jordan's 'Geological Map of London,' reviewed, 288.
Reports and Proceedings of Societies, 184, 234, 289.
Correspondence, 191, 239, 300.
Miscellaneous, 192, 240.

Geological Survey of India. Annual Report of the Museum of Geology. Calcutta, 1867.

——. Memoirs. Vol. vi. Part 3.

W. T. Blanford.—On the Geology of the Taptee and Lower Nerbudda Valleys, 163.
A. B. Wynne.—On Frog-beds in Bombay Island, 385.
F. Stoliczka.—On *Oxyglossus pusillus*, Owen, sp., 387.

——. Palæontologia Indica, being figures and descriptions of the Organic Remains procured during the progress of the Geological Survey of India. Vol. V. vii.–x. The Gasteropoda of the Cretaceous Rocks of Southern India, by Dr. F. Stoliczka. 1868.

——. Records. Vol. i. Parts 1–3. 1868.

W. T. Blanford.—On the Coal-seams of the Tawa Valley, 8.
H. B. Medlicott.—On the prospects of useful Coal being found in the Garrow-Hills, 11.
F. R. Mallet.—Copper in Bundelcund, 16.
W. T. Blanford.—On the Coal-seams of the neighbourhood of Chanda, 23.
——. Coal near Nagpur, 26.
A. B. Wynne.—Geological Notes on the Surat Collectorate, 27.
F. Stoliczka.—Additional Observations regarding the Cephalopodous Fauna of the South-Indian Cretaceous Deposits, 32, 56.
Coal in the Eastern Hemisphere, 37.
W. T. Blanford.—Notes on the Route from Poona to Nagpur, viâ Ahmednuggur, Jalna, Loonar, Yeotmahal, Mangali, and Hingunghat, 60.
T. Oldham.—On the Agate flake found by Mr. Wynne in the Pliocene (?) deposits of the Upper Godavery, 65.
H. B. Medlicott.—The boundary of the Vindhyan series in Rajpootana, 69.

——. ——. Vol. ii. Part 1. 1869.

A. B. Wynne.—The Valley of the Poorna River, West Berar, 1.
W. King.—On the Kuddapah and Kurnool Formations, 5.
H. B. Medlicott.—Geological Sketch of the Shillong Plateau, 10.
Val. Ball.—On the occurrence of Gold in the District of Singbhúm, 11.
H. B. Medlicott.—Memorandum of the Wells now being sunk at the European Penitentiary, and at the site for the Central Jail, Hazareebagh, 14.

Glasgow. Transactions of the Geological Society of Glasgow. Vol. iii. Part 2. 1869.

W. Thomson.—Geological Dynamics, 215.
J. W. Young.—On the Action of Organic Matter on Peroxide of Iron, as observed in the Post-Tertiary Sands of Glasgow, 241.
J. F. Potts.—On the Arran Claystones, 244.
H. M'Phial.—On the Carboniferous Sections of the Levern Valley, Renfrewshire, 254.
R. Craig.—Sketch of the Carboniferous Basin of Dalry, Ayrshire, 271.
J. Young.—Notes on the Section of Strata in the Gilmorehill Quarry, and Boulder-clay on the Site of the New University Buildings, Glasgow, 298.
J. Young and R. Craig.—Notes on the Occurrence of Seeds of Freshwater Plants and Arctic Shells, along with the remains of the Mammoth and Reindeer, in beds under the Boulder-clay at Kilmaurs, 310.
H. W. Crosskey and D. Robertson.—The Post-Tertiary Fossiliferous Beds of Scotland, 321.
J. Young.—From Geology to History, 341.
J. Burns.—Notes on the Post-Tertiary Deposits of the Carse of Falkirk, 367.

Good Health. A Journal of Physical and Mental Culture. Vol. i. Nos. 8–10. 1870.

Heidelberg. Verhandlungen des naturhistorisch-medizinischen Vereins. Band v. No. 3. October 1869.

Lancashire and Cheshire. Transactions of the Historic Society. New Series. Vol. ix. Session 1868–69.

Lausanne. Bulletin de la Société Vaudoise des Sciences Naturelles. Vol. x. No. 62. 1869.

J. J. Lochmann.—Rapport sur la marche des travaux de la Commission des Blocs Erratiques, 185 (3 plates).
H. Bischoff.—Analyse de l'eau minérale d'Yverdon, 190.
E. Renevier.—Coupes Géologiques du Bassin d'Yverdon, 265 (1 plate).
E. Hébert.—Sur les calcaires de Wimmis, 292.
E. Renevier.—Réponse aux observations de M. Hébert, 295.
P. Vionnet.—Notes sur quelques affleurements de la molasse, 329.

Linnean Society of London. Journal. Botany. Vol. xi. No. 53. 1870.

——. ——. Zoology. Vol. x. No. 48. 1870.

London, Edinburgh, and Dublin Philosophical Magazine. Fourth Series. Vol. xxxix. Nos. 261–263. *From Dr. W. Francis, F.G.S.*

H. Moseley.—On the "Veined Structure" of the Ice of Glaciers, 241 (1 plate).
— How.—Contributions to the Mineralogy of Nova Scotia, 275.
F. J. Pictet.—On the present state of the question as to the Limits of the Jurassic and Cretaceous Periods, 321.
A. R. Clarke.—On the course of Geodesic Lines on the Earth's Surface, 352.
Geological Society's Proceedings, 313, 383, 462.

Longman's Notes on Books. No. 61. May 1870.

Midland Scientific Association. Transactions. Part 2. 1870. *From the Rev. J. M. Mello, F.G.S.*

J. Ward.—The Fossil Fishes of the North Staffordshire Coal-field, 1.
E. Brown.—On an Ancient Bed of the River Trent, 37.
W. Stevenson.—The Fractured Condition and Decay of Magnesian Limestone, 47.

Monthly Microscopical Journal. Vol. iii. Nos. 16 & 17 (April and May).

Moscow. Bulletin de la Société Impériale des Naturalistes de Moscou. Année 1869. Nos. 1–3.

H. Trautschold.—Ueber säkulare Hebungen und Senkungen der Erdoberfläche, 1.
R. Hermann.—Untersuchungen über die Zusammensetzung des Fergusonits, 411.

Munich. Sitzungsberichte der königl.-bayer. Akademie der Wissenschaften zu München. 1869. Band ii. Hefte 3 & 4.

——. ——. 1870. Band i. Heft 1.

Nature (Journal). Vol. i. Nos. 21–26.

W. Mathews.—Mechanical Propeties of Ice, and their Relation to Glacier Motion, 534.
The existence of Man in the Tertiary Epoch, 580.
W. Boyd Dawkins.—Exploration of Caves at Settle, Yorkshire, 628.
J. Evans.—The Stone Age in Egypt, 631.
T. H. Huxley.—The Deep-Sea Soundings and Geology, 657.

——. Vol. ii. Nos. 27–33.

J. W. Flower.—Fossil Oysters, 22.
R. R. Stebbing.—Oysters of the Chalk, and the Theory of Development, 65.
J. Evans.—Stone Implements from Burma, 104.
W. Boyd Dawkins.—Fossil Mammals in North America, 119.

Neuchâtel. Bulletin de la Société des Sciences Naturelles de Neuchâtel. Tome viii. Deuxième cahier. 1869.

C. Knab.—Théorie de la Formation de l'Asphalte au Val-de-Travers et de la production des bitumes volatils en général, 226.

Neues Jahrbuch für Mineralogie, Geologie, und Paläontologie. Heft 7, 1869.

D. Burkart.—Ueber die geologische Erforschung der centralamerikanischen Republiken Guatemala und Salvador durch A. Dollfuss und R. de Montserrat, 769.
U. Schloenbach.—Beitrag zur Alters-Bestimmung des Grünsandes von Rothenfelde unweit Osnabrück, 808 (2 plates).

——. Heft 1. 1870.

T. Liebe.—Die Diabase des Voigtlandes und Frankenwaldes, 1.
D. Burkart.—Die Goldlagerstätten Californiens, 21.
G. vom Rath.—"Der Aetna in den Jahren 1863 bis 1866 mit besonderer Beziehung auf die grosse Eruption von 1865;" auszugsweise übertragen nach dem Werke von O. Silvestri, 51 (1 plate).

New York. The First Annual Report of the American Museum of Natural History. January 1870. (2 copies.)

Nova Scotia. Report of the Chief Commissioner of Mines for the Province of Nova Scotia, for the year 1869. 1870.

Offenbach-am-Main. Zehnter Bericht des Offenbacher Vereins für Naturkunde über seine Thätigkeit. 1868–69.

Paris. Annales des Mines. Tome xvi. Livr. 5 & 6. 1869.

De Boisset.—Note sur l'application du procédé Kind Chaudron au creusement de la fosse no. 4 de la compagnie des mines de l'Escarpelle, 371.
Castel.—Sur les Mines et usines métalliques du Banat, 405.
L. Gruner.—Notes additionnelles au Mémoire sur l'État actuel de la Métallurgie du Plomb, 518.
Domeyko.—Sur quelques Minéraux du Chili, 537.
Mussy.—Ressources Minérales de l'Ariége, 547.
Terrains aurifères récemment découverts dans le nord de l'Écosse, 597.
Sur les mines d'or, d'argent et d'étain récemment découvertes dans les environs de los Angeles (Californie), 599.
Rapport sur l'industrie minière et métallurgique en Italie, 600.
Notice statistique sur l'industrie minérale de la province du Hainaut, 627.
Production des mines, salines et usines, dans les pays faisant partie du Zollverein, 632.
Gruner.—Supplément aux Notes additionnelles sur la métallurgie du plomb, 634.

——. Bulletin de la Société Géologique de France. Deuxième Série. Tome xxvi. Nos. 5 & 6. 1869.

Coquand.—La Craie, sa composition et son origine, 545.
De Mortillet.—Classification chronologique de l'époque de la pierre éclatée, etc., 583.
Hébert.—Sur les caractères de la faune des calcaires de Stramberg et sur l'âge des couches de l'étage tithonique, 588.
Leymerie.—Récit d'une exploration géologique de la vallée de la Sègre, 604 (1 plate).
Chaper.—Observations sur la note ci-dessus de M. Hébert, 668.
Marcou.—Notes sur l'origine de l'étage tithonique, 669.
Hébert.—Réponse à MM. Chaper et Marcou à propos de l'âge des calcaires à *Terebratula diphya* de la Porte-de-France, 671.
Whitney.—Découverte de restes humains et de traces du travail de l'homme dans des roches tertiaires en Californie, 676.
C. Grad.—Sur la formation et la constitution des lacs des Vosges, 677.
——. Observations sur les glaciers du Grindelwald, 687.
Levallois.—Notice biographique sur C. E. Thirria, 693.
Alb. de Lapparent.—Discours sur les récents progrès de la géologie, 716.
De Tchihatcheff.—Quelques mots sur son ouvrage intitulé : Géologie de l'Asie mineure, 737.
Daubrée.—Considérations sur le même ouvrage, 740.

Paris. Bulletin de la Société Géologique de France. Deuxième Série. Tome xxvi. Nos. 5 & 6 (*continued*).

Dufour.—Sur le pseudomorphisme des roches feldspathiques, 744.
——. Sur un Singe probablement subfossile, 746.
Raulin.—De l'opinion de L. Cordier sur les ophites des Pyrénées, 747.
De Saporta.—Sur son ouvrage intitulé Études sur la végétation du S. E. de la France à l'époque tertiaire, 751.
——. Sur l'existence de plusieurs espèces actuelles observées dans la flore pliocène de Meximieux (Ain), 752.
Tournouër.—Sur la faune des coquilles fossiles des tufs de Meximieux (Ain), 774.
Gervais.—Restes fossiles du Glouton recueillis en France, 777.
Bourassin.—Sur les blocs granitiques des environs de Concarneau et de Tréguier, 779.
Matheron.—Sur les reptiles fossiles des dépôts fluvio-lacustres crétacés du bassin à lignites de Fuveau, 781.
Toucas.—Description géologique et paléontologique du canton du Bausset (Var), 796 (1 plate).
Garrigou.—Note sur le niveau des cavernes, 825.
Coquand et Boutin.—Sur les relations qui existent entre la formation jurassique et la formation crétacée des cantons de Ganges, de St. Hippolyte et de Sumène, 834.
Coquand.—Comparaison des terrains de Ganges avec d'autres terrains analogues, et constatation des étages kimméridgien et portlandien fossilifères dans la Provence, 854.
Belgrand.—L'âge des tourbes dans la bassin de la Seine, 879 (1 plate).

——. Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences. Deuxième Semestre 1869. Tome lxix. Nos. 23–26.

Reboux.—Recherches archéopaléontologiques, 1260.
Hamy et Lenormant.—Sur quelques ateliers superficiels de silex récemment découverts en Égypte, 1313.
Grad.—Sur la présence de dépôts stratifiés dans les moraines, et les oscillations séculaires des glaciers du Grindelwald, 1315.
Pissis.—Note sur la structure stratigraphique du Chili, 1319.

——. ——. Premier Semestre 1870. Tome lxx. Nos. 1–14.

E. Ollivier.—Secousses de tremblements de terre à Biskra (Algérie du Sud), du 16 au 19 novembre inclusivement, 48.
Helmersen.—Étude sur les blocs erratiques et sur les dépôts diluviens de la Russie, 51.
B. Renault.—Notices sur quelques végétaux silicifiés des environs d'Autun, 119.
Schafaritz.—Découverte au diamant à Dlaschkowitz (Bohème), 140.
Bianconi.—Recherches sur les affinités naturelles de l'*Æpyornis*, 162.
Cotteau.—Sur le genre *Asterostoma*, de la famille des Échinocorydées, 271.
Gorceix.—Sur l'état actuel du volcan de Santorin, 274.
Boussingault.—Observations relatives à l'époque de l'éruption du volcan de Purace, 503.

Paris. Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences. Premier Semestre 1870. Tome lxx. Nos. 1–14 (*continued*).

Magnan.—Sur le terrain de craie des Pyrénées françaises et des Corbières, et notamment sur la partie inférieure de cette formation (néocomien, aptien, albien), 537.

Roujou et Julien.—Note sur des stries observées sur des blocs de grès de Fontainebleau, de meulière de la Brie, de silex et de calcaire grossier engagés dans les diluviums des environs de Paris, 538.

Alph. Milne-Edwards.—Observations sur la faune ornithologique du Bourbonnais pendant la période tertiaire moyenne, 557.

Leveillé.—Note relative à la découverte de restes de l'homme quaternaire dans les ateliers de pierre taillée et polie du Grand-Pressigny (Indre-et-Loire), 566.

Richard.—Découverte d'instruments de l'âge de pierre en Arabie et en Égypte, 576.

Leymerie.—Observations sur une Note récente de M. Magnan, relative au terrain crétacé inférieur des Pyrénées, 694.

——. Note sur l'état fragmentaire des hautes cimes des Pyrénées, 695.

——. Revue des Cours Scientifiques de la France et de l'Étranger. Septième Année. Nos. 17–29. March to June 1870.

A. Favre.—De l'Existence de l'Homme à l'Époque Tertiaire, 267.

É. Blanchard.—Les travaux scientifiques des départements en 1869–70, 354.

T. H. Huxley.—La Paléontologie depuis huit ans, 450.

Philadelphia. Journal of the Academy of Natural Sciences of Philadelphia. New Series. Vol. vi. Part 4. 1869.

——. ——. Vol. vii. 1869.

F. V. Hayden.—On the Geology of the Tertiary Formations of Dakota and Nebraska, 9.

J. Leidy.—Extinct Mammalia of Dakota and Nebraska, including an account of some allied forms from other localities, 23.

——. Proceedings of the Academy of Natural Sciences of Philadelphia. Nos. 1 & 2. January to July 1869.

J. Lea.—Notes on Microscopic Crystals in some Minerals, 4, 119.

E. D. Cope.—Third Contribution to the Fauna of the Miocene Period of the United States, 6.

J. Leidy.—Notice of some Extinct Vertebrates from Wyoming and Dakota, 63.

F. B. Meek and A. H. Worthen.—Descriptions of new Crinoidea and Echinoidea from the Carboniferous Rocks of the Western States, with a Note on the Genus *Onychaster*, 67.

——. Remarks on the Blastoidea, with description of new species, 83.

——. Description of new Carboniferous Fossils from the Western States, 137.

Photographic Society. Journal. Nos. 216–218. April to June 1870.

Puy. Annales de la Société d'Agriculture, Science, Arts et Commerce du Puy. Tome xxix. 1868.

Quarterly Journal of Science. No. 26. April 1870.

S. P. Oliver.—Megalithic Structures of the Channel Islands: their History and Analogues, 149.
Chronicles of Geology and Mineralogy, 269, 280.

Quekett Microscopical Club. Journal. No. 10. April 1870.

Royal Geographical Society. Journal. Vol. xxxix. 1869.

Royal Irish Academy. Transactions. Vol. xxiv. Antiquities. Part 8. 1867.

——. ——. Vol. xxiv. Literature. Part 4. 1867.

——. ——. Vol. xxiv. Science. Parts 9–15. 1867–70.

W. King.—On the Histology of the Test of the Class Palliobranchiata, 439.

Royal Society. Proceedings. Vol. xviii. Nos. 117–119.

R. Owen.—On the Fossil Mammals of Australia. Part 3. *Diprotodon australis*, Owen, 196.
P. M. Duncan.—On the *Madreporaria* dredged up in the Expedition of H.M.S. 'Porcupine,' 289.
S. Haughton.—On the Constituent Minerals of the Granites of Scotland, as compared with those of Donegal, 312.

Scientific Opinion. Vol. iii. Nos. 73–85. March to June 1870.

A. Murray.—Origin of Gold Nuggets and Gold Dust, 320.
J. C. Ward.—A Geological Dream on Skiddaw, 345, 364, 383.
W. Boyd Dawkins.—Settle-Cave Exploration, 366.
G. H. Kinahan.—Notes on the Nomenclature of Ingenite (Intrusive) Rocks, 381.
The Sulphur-beds of California, 381.
T. P. Barkas.—New, Rare, and Obscure Fossils from the Northumberland Coal-measures, 400.
G. H. Kinahan.—On the Ancient Iron Trade of Ireland, 460, 480, 501.

Society of Arts. Journal. 116th Session. Nos. 905–917.

Strasbourg. Bulletin de la Société des Sciences Naturelles. 1re Année. Nos. 1–11.

——. ——. 2e Année. Nos. 1–7.

C. Grad.—Observations sur les glaciers du Grindelwald, 75.

——. Mémoires de la Société des Sciences Naturelles de Strasbourg. Tome vi. 2me livraison. 1870.

Student and Intellectual Observer. New Series. Vol. i. No. 2. April 1870.

Teign Naturalists' Field-club. Report of the Proceedings for the year 1869.

Vienna. Anzeiger der k.-k. Akademie der Wissenschaften in Wien. 1870. Nos. 7–12.

——. Denkschriften der kaiserlichen Akademie der Wissenschaften. Math.-natur. Classe. Band xxix. Erste Abtheilung. 1869.

C. v. Ettingshausen.—Die fossile Flora des Tertiär-Beckens von Bilin, 1 (16 plates).
K. F. Peters.—Zur Kenntniss der Wirbelthiere aus den Miocänschichten von Eibiswald in Steiermark. I. Die Schildkrötenreste, 111 (3 plates); II. *Amphicyon*, *Viverra*, *Hyotherium*, 189 (3 plates).
F. Unger.—Die fossile Flora von Radoboj in ihrer Gesammtheit und nach ihrem Verhältnisse zur Entwickelung der Vegetation der Tertiärzeit, 125 (5 plates).
A. E. Reuss.—Paläontologische Studien über die älteren Tertiärschichten der Alpen. II. Abtheilung. Die fossilen Anthozoen und Bryozoen der Schichtengruppe von Crosara, 215 (20 plates).

——. ——. ——. Band xxix. Zweite Abtheilung.

G. C. Laube.—Ein Beitrag zur Kenntniss der Echinodermen des Vicentinischen Tertiärgebietes, 1 (7 plates).

——. Sitzungsberichte der k.-k. Akademie der Wissenschaften. Band lix. Erste Abtheilung. Hefte 3–5. 1869.

A. Boué.—Ueber den wahrscheinlichsten Ursprung der Salzlagerstätten, 321.
F. Toula.—Ueber einige Fossilien des Kohlenkalkes von Bolivia, 433 (1 plate).
A. E. Reuss.—Zur fossilen Fauna der Oligocänschichten von Gaas, 446 (6 plates).
A. Manzoni.—Bryozoi fossili Italiani. Seconda Contribuzione, 512 (2 plates).
A. Auerbach.—Krystallographische Untersuchung des Cölestins, 349 (10 plates).
E. Bořický.—Zur Entwicklungsgeschichte der in dem Schichtencomplex der silurischen Eisensteinlager Böhmens vorkommenden Minerale, 589.
A. E. Reuss.—Ueber hemimorphe Barytkrystalle, 623.
F. Simony.—Ueber Urgesteinsablagerungen im obersten Traunthale, 722 (1 plate).

——. ——. Band lix. Zweite Abtheilung. Hefte 4 & 5. 1869.

——. ——. Band lx. Erste Abtheilung. Hefte 1 & 2. 1869.

G. Tschermak.—Mikroskopische Unterscheidung der Mineralien aus der Augit-, Amphibol- und Biotitgruppe, 5 (2 plates).
C. v. Ettingshausen.—Beiträge zur Kenntniss der Tertiärflora Steiermarks, 17 (6 plates).
G. Tschermak.—Ueber einen Feldspath aus dem Närödal und über das Mischungsgesetz der plagioklastischen Feldspathe, 145.
H. Abich.—Die Fulguriten im Andesit des kleinen Ararat, nebst Bemerkungen über östliche Einflüsse bei der Bildung elektrischer Gewitter, 153.
W. v. Haidinger.—Mittheilungen von Herrn kais. russ. Staatsrath Hermann Abich in Tiflis, 162.

Vienna. Sitzungsberichte der k.-k. Akademie der Wissenschaften. Band lx. Zweite Abtheilung. Hefte 1 & 2. 1869.

——. Jahrbuch der k.-k. geologischen Reichsanstalt. Band xix. Nos. 3 & 4. 1869.

D. Stur.—Die Braunkohlen-Vorkommnisse im Gebiete der Herrschaft Budafa in Ungarn, 341 (1 plate).

M. Neumayr.—Beiträge zur Kenntnisse tertiärer Binnenfaunen, 355 (4 plates).

J. Szabó.—Die Amphibol-Trachyte der Mâtra in Central-Ungarn, 417.

K. v. Hauer.—Arbeiten in dem chemischen Laboratorium der k.-k. geologischen Reichsanstalt, 427.

F. Bunzel.—Dr. W. B. Carpenter's vorläufiger Bericht über Schleppnetz-Untersuchungen in den nördlich von den britischen Inseln gelegenen Meeresregionen auf Ihrer Majestät Dampfer "Lightning" übersetzt, 435.

D. Stur.—Die Bodenbeschaffenheit der Gegenden südöstlich bei Wien, 465.

F. v. Hauer.—Geologische Uebersichtskarte der österreichisch-ungarischen Monarchie. Blatt No. iii. Westkarpathen, 485.

E. v. Mojsisovics.—Beiträge zur Kenntniss der Cephalopoden-Fauna des alpinen Muschelkalkes, 567 (6 plates).

F. v. Vivenot.—Beiträge zur mineralogischen Topographie von Oesterreich und Ungarn, 595.

D. Stur.—Ueber die Verhältnisse der wasserführenden Schichten im Ostgehänge des Tafelberges bei Olmütz, 613 (1 plate).

——. Verhandlungen der k.-k. geologischen Reichsanstalt. 1870. Nos. 5–7.

G. L. Griesbach.—Petrefactenfunde in Südafrika, 75.

A. Hořinek.—Ueber die im Kaiser-Franz-Joseph-Stollen zu Hallstatt gemachten Gebirgsaufschlüsse, 76.

U. Schloenbach.—Notiz über eine neue von St. Petersburg ausgehende, geographisch-naturwissenschaftliche Expedition nach dem Kaukasus, 78.

O. F. v. Petrino.—Ueber die nachpliocänen Ablagerungen, insbesondere über Löss und über die Wichtigkeit der Erforschung dieser Bildungen als Grundlage für die landwirthschaftliche Bodenkunde, 79.

E. Bunzel.—Ueber die Reptilien-Fauna der Kreideschichten von Grünbach, 80.

K. v. Hauer.—Ueber den Kainit von Kalusz, 80.

D. Stur.—Beiträge zur Kenntniss der Dyas- und Steinkohlenformation im Banate, 81.

F. Pošepný.—Vorlage der geologisch-montanistischen Generalkarte des Goldbergbau-Reviers von Verespatak in Siebenbürgen, 95.

E. Bunzel.—Die Foraminiferen des Tegels von Brünn, 96.

T. Fuchs.—Die Fauna der Congerienschichten von Radmanest bei Lugos im Banate, 96.

K. v. Hauer.—Vercokungsversuche mit Fohnsdorfer Kohle, 97.

R. Knapp.—Das Kohlenvorkommen von Bersaska im serbisch-banater Grenz-Regimente Nr. 14, 100.

K. Zittel.—Grenzschichten zwischen Jura und Kreide, 113.

K. Hoffmann.—Dolomite und Kalke des Ofner-Gebirges, 116.

Vienna. Verhandlungen der k.-k. geologischen Reichsanstalt. 1870. Nos. 5–7 (*continued*).

F. v. Andrian.—Geologische Studien aus dem Orient. I. Die vulcanischen Gebilde des Bosphorus, 118.
E. Tietze.—Mittheilungen über den neiderschlesischen Culm und Kohlenkalk, 118.
— Woldrich.—Vorkommen von Kössener Schichten bei Salzburg, 123.
C. M. Paul.—Ueber das Lignitvorkommen in Westslavonien, 123.
U. Schloenbach.—Ueber neuer Vorkommnisse aus dem alpinen und böhmischen Kreidegebiete, 123.
F. Pošepný.—Ueber alpine Erzlagerstätten, 124.
U. Schloenbach.—Vorkommen des *Amm.* (*Phyll.*) *ultramontanus*, Zitt., im Dogger von Csernye im Bakonyer Walde, 133.
E. Tietze.—Die Devon-Schichten bei Gratz, 134.
A. Bielz.—Geologische Notizen aus Siebenbürgen, 136.
E. v. Mojsisovics.—Durchschnitt von Stramberg nach Nesselsdorf (Mähren), 136.
H. Wolf.—Neue geologische Aufschlüsse in der Umgebung von Wien durch die gegenwärtigen Eisenbahnarbeiten, 139.

——. Verhandlungen der k.-k. zoologisch-botanischen Gesellschaft in Wien. Band xix. 1869.

Warwick. Proceedings of the Warwickshire Naturalists' and Archæologists' Field-club. 1869.

York. Annual Report of the Council of the Yorkshire Philosophical Society for 1869.

Yorkshire Naturalists' Club. Proceedings. 1869.

Zoological Society. Proceedings. 1869. Part 2 (March to June).

——. ——. 1869. Part 3 (November and December).

——. Transactions. Vol. vii. Parts 1 & 2. 1869–70.

II. PERIODICALS PURCHASED FOR THE LIBRARY.

Annales des Sciences Géologiques. Tome i. No. 2. 1870.

E. Hébert.—Recherches sur l'âge des grès à combustibles d'Helsingborg et d'Höganäs, 145.
L. Lartet.—Essai sur la Géologie de la Palestine et des contrées avoisinantes, 149.

Annales des Sciences Naturelles. Zoologie et Paléontologie. 5[e] Série. Tome xiii. 1870.

Bianconi.—Recherches sur les affinités naturelles de l'*Æpyornis*, article 11.

Annals and Magazine of Natural History. Fourth Series. Vol. v. Nos. 28–30. April to June 1870.

E. Billings.—Notes on the Structure of the *Crinoidea, Cystidea,* and *Blastoidea*, 251, 409.

A. Hancock and Thomas Atthey.—Notes on an undescribed Fossil Fish from the Newsham Coal-shale near Newcastle-upon-Tyne, 266.

H. G. Seeley.—On *Ornithopsis*, a Gigantic Animal of the Pterodactyle kind from the Wealden, 279.

——. On *Zoocapsa dolichorhamphia*, a Sessile Cirripede from the Lias of Lyme Regis, 283.

H. A. Nicholson.—On the British species of *Didymograpsus*, 337 (1 plate).

A. Hancock.—On the Occurrence of *Loxomma Allmanni* in the Northumberland Coal-field, 374.

W. Carruthers.—On the Structure of a Fern-stem from the Lower Eocene of Herne Bay, and on its allies, recent and fossil, 450.

A. Milne-Edwards.—Observations on the Ornithological Fauna of the Bourbonnais during the middle Tertiary period, 451.

Journal de Conchyliologie. Vol. x. Nos. 2 & 3. 1870.

E. Dumortier.—Note sur une espèce nouvelle d'*Avelana* du Lias supérieur, 307.

A. Bezançon.—Description d'espèces nouvelles du bassin de Paris, 310.

C. Mayer.—Description de coquilles fossiles des terrains tertiaires inférieurs, 323.

A. Bell.—Catalogue des Mollusques fossiles des marnes bleues de Biot (Alpes-maritimes), 338.

R. Tournouer.—Description de quelques Auriculacés nouveaux des terrains tertiaires, 356.

Palæontographica: herausgegeben von Dr. W. Dunker und Dr. K. A. Zittel. Vol. xix. Part 3 and Suppl.

E. Tietze.—Ueber die devonischen Schichten von Ebersdorf unweit Neurode in der Grafschaft Glatz, 103 (2 plates).

III. GEOLOGICAL AND MISCELLANEOUS BOOKS.

Names of Donors in Italics.

Abich, H. Der Ararat, in genetischer Beziehung betrachtet. 8vo. 1870.

Ansted, D. T. The Physical Geography and Geology of the County of Leicester. 4to. 1866.

Barrande, J. Distribution des Céphalopodes dans les Contrées Siluriennes. Extrait du Syst. Silur. du Centre de la Bohême, Vol. ii. 8vo. 1870.

Barrande, J. Système Silurien du Centre de la Bohême. Vol. ii. Pls. 351–460. 4to. 1870.

Belgrand, E. Le Bassin Parisien aux Ages Antéhistoriques. Text and Plates. 4to. Paris, 1869.

Binney, E. W. Note on the Organs of Fructification and Foliage of *Calamodendron commune* (?). 8vo. 1870.

——. On the Permian Strata of East Cheshire. 8vo. 1870.

Bowerbank, J. S. On the Sea-beach question. 8vo. 1870.

Brandt, F. Neue Untersuchungen über die in den altaischen Höhlen aufgefundenen Säugethierreste, ein Beitrag zur quaternären Fauna des russischen Reiches. 8vo. St. Petersburg. 1870.

——. Ueber das Haarkleid des ausgestorbenen nordischen (büschelhaarigen) Nashorns (*Rhinoceros tichorhinus*). 8vo. 1869.

——. Ueber die von Herrn Magister Adolph Goebel auf seiner persischen Reise bei der Stadt Maragha in der Provinz Aderbeidjan gefundenen Säugethier-Reste. 4to. 1870.

Bridet.—Étude sur les Ouragans de l'Hémisphère Austral. 8vo. Paris, 1869. *Presented by the Dépôt de la Marine.*

Brodie, P. B. Practical Geology; read in place of the Annual Address at the winter Meeting of the Warwickshire Naturalists' Field Club. 8vo. 1869.

Catalogue Chronologique des Cartes, Plans, Vues de Côtes, Mémoires, Instructions Nautiques, &c. 8vo. Paris, 1869. *Presented by the Dépôt de la Marine.*

Catalogue par Ordre Géographique des Cartes, Plans, Vues de Côtes, Mémoires, Instructions Nautiques, &c. 8vo. Paris, 1869. *Presented by the Dépôt de la Marine.*

Catalogue of Maps of the British Possessions in India and other parts of Asia. 8vo. 1870. *From the Secretary of State for India.*

Catlin, G. The Lifted and Subsided Rocks of America, with their Influences on the Oceanic, Atmospheric, and Land-currents, and distribution of Races. 8vo. 1870.

Ceselli, L. Esposizione Descrittiva ed Analitica sui Minerali dei dintorni di Roma e della Quiritina (Nuovi Minerali). 8vo. Rome, 1865.

——. Memoria sopra i Colli Giannicolesi per servire alla Geologia Romana in occasione del ritrovamento di un Decapodo sul Monte Mario. 8vo. Rome, 1848.

Ceselli, L. Sopra l'Arte Ceramica primitiva nel Lazio. 4to. Rome, 1868.

——. Sopra una Tartaruga trovata alle acque caje di Viterbo. 8vo. 1846.

——. Stromenti in Silice della Prima Epoca della pietra della Campagna Romana. 8vo. Rome, 1866.

Chambeyron et Banaré. Instructions Nautiques sur la Nouvelle-Calédonie. 8vo. Paris, 1869. *Presented by the Dépôt de la Marine.*

Charts and Plans of the Coast of various parts of the World. Numbered 2513 to 2841. *Presented by the Dépôt des Cartes et Plans de la Marine.*

Cloué, G. C. Pilote de Terre-Neuve. Tomes 1 & 2. 8vo. Paris, 1869. *Presented by the Dépôt de la Marine.*

Croll, J. On Ocean-currents. 8vo. 1870.

——. The Boulder-clay of Caithness a Product of Land-ice. 8vo. 1870.

Daubrée, A. Note sur l'existence de gisements de bauxite dans les départements de l'Hérault et de l'Ariége. 8vo. Paris, 1869.

Duncan, P. M. On *Palæocoryne*, a Genus of Tubularine Hydrozoa from the Carboniferous Formation. 4to. 1869.

Eichwald, E. von. Nils von Nordenskiöld und Alexander von Nordmann nach ihren Leben und Wirken geschildert. 8vo. St. Petersburg, 1870.

Evans, C. On some Sections of Chalk between Croydon and Oxtead. 8vo. 1870.

Frickmann. Instructions pour la Navigation de la Côte Ouest d'Ecosse. 8vo. Paris, 1869. *Presented by the Dépôt de la Marine.*

Fuchs, T. Beitrag zur Kenntniss der Conchylienfauna des Vicentinischen Tertiärgebirges. Abth. I. 4to. Wien, 1870.

——. Die Conchylienfauna der Eocänbildungen von Kalinowka im Gouvernement Cherson im südlichen Russland. 8vo. St. Petersburg, 1869.

Gaussin. Annuaire des Marées des Côtes de France pour l'an 1870. 12mo. Paris, 1869. *Presented by the Dépôt de la Marine.*

Geinitz, H. B., and C. T. Sorge. Uebersicht der im Königreiche Sachsen zur Chausseeunterhaltung verwendeten Steinarten. 4to. Dresden, 1870.

Gras, A. Annales Hydrographiques. Recueil d'avis, instructions, documents et mémoires relatif à l'hydrographie et à la navigation. 4e trimestre de 1868, and 1r–3e trimestres de 1869. *Presented by the Dépôt de la Marine.*

——. Description des Côtes du Royaume de Portugal. 8vo. Paris, 1869. *Presented by the Dépôt de la Marine.*

——. Routier des Côtes N.-O., Ouest et Sud d'Espagne. 8vo. Paris, 1869. *Presented by the Dépôt de la Marine.*

Grye, B. de la. Note sur les Sondes faites par de grandes profondeurs. 8vo. Paris, 1869. *Presented by the Dépôt de la Marine.*

——. Pilote des Côtes Ouest de France. Tome I. 8vo. Paris, 1869. *Presented by the Dépôt de la Marine.*

Gümbel. Ueber den Riesvulkan und über vulkanische Erscheinungen im Rieskessel. 8vo. 1870.

Haidinger, W. v. Das Kaiserlich-Königliche Montanistische Museum und die Freunde der Naturwissenschaften in Wien in den Jahren 1840 bis 1850. 8vo. Wien, 1869.

Hasskarl, C. Commelinaceæ Indicæ, Imprimis Archipelago Indici. 8vo. Vindobonæ, 1870.

Hébert, E. Classification des assises néocomiennes. Réponse aux critiques de M. Coquand. 8vo. Paris, 1868.

——. Examen de quelques points de la géologie de la France méridionale. 8vo. Paris, 1869.

——. Notice des Travaux Scientifiques. 4to. Paris, 1869.

——. Observations sur les caractères de la faune des calcaires de Stramberg (Moravie), et en général sur l'âge des couches comprises sous la désignation d'Étage tithonique. 8vo. Paris, 1869.

——. Observations sur les couches inférieures de l'infra-lias du Midi de la France. 8vo. Paris, 1869.

——. Recherches sur la craie du nord de l'Europe. 4to. Paris, 1866.

——. Recherches sur l'âge des Grès à Combustibles d'Helsingborg et d'Hogänäs (Suède Méridionale) suivies de quelques aperçus sur les Grès de Hör. 8vo. Paris, 1869.

——. Réponse à MM. Marcou et Chaper, à propos de la discussion sur l'âge des calcaires à *Terebratula diphya* de la Porte-de-France. 8vo. Paris, 1869.

——. Sur les couches comprises, dans le Midi de la France, entre les calcaires oxfordiens et le néocomien marneux à *Belemnites dilatatus,* en réponse à M. Coquand. 8vo. Paris, 1868.

Helmersen, G. von. Zur Steinkohlenangelegenheit in Russland. 8vo. 1869.

Hind, H. Y. The Gold-mining and its Prospects in Nova-Scotia. 8vo. 1870. *From Prof. J. Tennant, F.Z.S.*

Jeffreys, J. Gwyn. Norwegian Mollusca. 8vo. 1870.

Jones, T. R. Notes on the Tertiary Entomostraca of England. 8vo. 1870.

——. On some Bivalved Entomostraca from the Coal-measures of South Wales. 8vo. 1870.

Kenrick, J. The Inscribed Tablet of Dhibân, known as "The Moabite Stone." 8vo. 1870. *Presented by the Yorkshire Philosophical Society.*

King, W., and Rowney, T. H. On *Eozoon Canadense.* 8vo. Dublin, 1870.

Kjerulf, —. The Terraces of Norway. Translated from the Norsk by *Marshall Hall, F.G.S.* 8vo. 1870.

Lorenz, L. Experimentale og theoretiske Undersögelser over Legemernes Brydningsforhold. 4to. Copenhagen, 1869.

Lubbock, J. Pre-historic Times. 2nd edition. 8vo. 1869.

McDougall, G. F. Instructions Nautiques pour la Côte Sud-ouest de la Nouvelle-Écosse et Baie de Fundy. 8vo. Paris, 1869. *Presented by the Dépôt de la Marine.*

Marsh, O. C. Description of a New and Gigantic Fossil Serpent, *Dinophis grandis,* from the Tertiary of New Jersey. 8vo. 1869.

——. Notice of some Fossil Birds from the Cretaceous and Tertiary Formations of the United States. 8vo. 1870.

——. Description of a new species of *Protichnites* from the Potsdam Sandstone of New York. 8vo. 1869.

——. Notice of some new Mosasauroid Reptiles from the Greensand of New Jersey. 8vo. 1869.

Mayer, C. Catalogue Systématique et Descriptif des Fossiles des Terrains Tertiaires qui se trouvent au Musée Fédéral de Zurich. Parts 2–4, *Mollusques.* 8vo. Zurich, 1867–70.

——. Description de Coquilles Fossiles des Terrains Tertiaires Inférieurs. 8vo. 1870.

——. Tableau Synchronistique des Terrains Tertiaires Supérieurs. 4e édition. Zurich, 1868.

——. Tableau Synchronistique des Terrains Tertiaires de l'Europe. 3e édition. Zurich, 1865.

Mayer, C. Tableau Synchronistique des Terrains Tertiaires Inférieurs. 4e édition. Zurich, 1869.

Mojsisovics, E. v. Beiträge zur Kenntniss der Cephalopoden-fauna des alpinen Muschelkalkes. 8vo. Wien, 1870.

Montagna, C. Nouvelle Théorie du Métamorphisme des Roches fondée sur les Phénomènes de Fossilisation des Animaux et des Plantes de tous les âges géologiques. 8vo. Naples, 1869.

Moore, C. Report on Mineral Veins in Carboniferous Limestone and their Organic contents. 8vo. 1869.

——. The Mammalia and other Remains from Drift Deposits in the Bath Basin. 8vo. Bath, 1870.

Mouchez, E. Les Côtes du Brésil, descriptions et instructions nautiques. 8vo. Paris, 1869. *Presented by the Dépôt de la Marine.*

Murchison, R. I. Address at the Anniversary Meeting of the Royal Geographical Society, May 23rd, 1870.

Murray, A. Report upon the Geological Survey of Newfoundland for the year 1869. 8vo. St. John's, Newfoundland, 1870. *Presented by Earl Granville.*

Newberry, J. S. The Geological Survey of Ohio, its Progress in 1869. Report of an Address delivered to the Legislature of Ohio. 8vo. 1870.

Noyers, S. des. Pilote de la Manche. 8vo. Paris, 1869. *Presented by the Dépôt de la Marine.*

Ordnance Survey Maps of the United Kingdom, 1-inch scale. England: Sheets 101 N.E., 108 N.E. and S.E. Scotland: Sheet 31. Ireland: Sheets 33, 73, 83, 98, and 130.

——, 6-inch scale. Aberdeen: 43, 44, 46–48, 51–57, 59–63, 66, 68–71, 75, 80–82, 86, 92, 94, 101. Argyll: 174, 213, 242, 246. Pembroke 33, 34, 38–40, 42, 43. *From the Secretary of State for War.*

Planche, H. de la. Pilote de la Mer Noire. Paris, 1869. *Presented by the Dépôt de la Marine.*

Quetelet, A. Notice sur le Congrès Statistique de Florence en 1867.

——. Observations des Phénomènes Périodiques pendant les Années 1867 et 1868. 4to. 1869.

Rickard, F. I. The Mineral and other Resources of the Argentine Republic (La Plata) in 1869. 8vo. 1870.

Roujoux, H. de. Essai sur l'Atterrage et l'Entrée de la Rade de Brest par temps brumeux, avec un bâtiment à vapeur. 8vo. Paris, 1868. *Presented by the Dépôt de la Marine.*

Schloenbach, U. Beitrag zur Altersbestimmung des Grünsandes von Rothenfelde unweit Osnabrück. 8vo. Stuttgart, 1869.

Seeley, H. G. Ornithosauria, an elementary study of the Bones of *Pterodactyles.* 8vo. Cambridge, 1870.

Steen, A. Om Œndringen af Integraler af irrationale Differentialer til Normalformen for det elliptiske Integral af förste Art. 4to. Copenhagen, 1869.

Stoppani, A. Paléontologie Lombarde. Deuxième Série, Livr. 1–9. Monographie des Mammifères fossiles de la Lombardie, par E. Cornalia. *Presented by E. Cornalia.*

Thomsen, J. Thermochemiske Undersögelser over Affinitetsforholdene imellem Syrer og Baser i vandig Oplösning. 4to. Copenhagen, 1869.

Trautschold, H. von. Geognostisches über den Kreis Mjeschtschowsk im Gouvernement Kaluga vom Fürsten P. Kropotkin, nebst paläontologischen Beiträge. 8vo. Moscow, 1870.

Victoria. Report of the Mining Surveyors and Registrars. Quarters ending 31st December, 1869, and 31st March, 1870. *From the Government of Victoria.*

Winkler, T. C. Description d'un Crinoïde et d'un Poisson du Système Hærsien. 8vo. Harlem, 1869.

Zeuschner, L. Beschreibung des artesischen Brunnens in Ciechocinek bei Thoren, erbohrt im April 1861. 8vo. Moskau, 1864. (2 copies.)

——. Beschreibung neuer Arten oder eigenthümlich ausgebildeter Versteinerungen. 8vo. 1870.

——. Die Entwickelung der Jura-Formation in westlichen Polen. 8vo. 1864.

——. Die Gruppen und Abtheilungen des pölnischen Juras, nach neueren Beobachtungen zusammengestellt. 8vo. 1869.

——. Einige Bemerkungen über die geognostische Karte von Oberschlesien, bearbeitet von Herrn Ferdinand Rœmer. 8vo. 1870.

——. O dolomicie w pasmie Dewónskiém rozpostartém pomiędzy Chęcinami a Sandomierzem. 8vo. 1868.

——. Ueber eine alte Längenmoräne im Thale des Bialy Dunajec bei dem Hochofen von Zakopane in der Tatra.

——. O Mijocenicznych Gipsach i Pokladach Soli Kuchennéj w Górnéj Częsci Doliny Wisly, przy Krakowie. 8vo. 1863.

Zeuschner, L. Opis Zoologiczny, Botaniczny i Geologiczny wszystkich Zwierząt i Róślin Skamienialych Polskich do Poznania warstem ziemi Slużący. 8vo. 1845.

——. O rozwoju Sredniego Ogniwa Formacyi Dewońskíej pomiędzy Grzegorzewicami a wioskami Skaly i Zagaje przy Nowéj Slupi pod górą Swiętokrzyzką. 8vo. 1868.

——. O wierzchniém ogniwie eoceniczném w dolinach Wlasciwych i Niżnych Tatrów. 8vo. 1860.

——. Ueber das Alter der Grauwackenschiefer und der bräunlichgrauen Kalksteine von Swientomarz bei Bodzentyn im Kielcer Uebergangs-Gebirge. 8vo. 1866.

——. Ueber das Vorkommen von *Diceras arietaria* in Korzetzko bei Chenciny. 8vo. 1868.

——. Ueber den Dolomit im devonischen Gebirgszuge zwischen Sandomierz und Chenciny. 8vo. St. Petersburg, 1868.

——. Ueber die eigenthümliche Entwickelung der triasischen Formationen zwischen Brzeziny und Pierzchnica am südwestlichen Abhange des paläozoischen Gebirges zwischen Sandomierz und Chenciny. 8vo. 1868.

—— Ueber die neuentdeckte Silurformation von Kleczanów bei Sandomierz im südlichen Polen. 8vo. 1869.

——. Ueber die rothen und bunten Thone und die ihnen untergeordneten Glieder im südwestlichen Polen. 8vo. 1866.

——. Ueber die verschiedenen Formationen auf die sich der Jura in Polen abgesetzt hat. 8vo. St. Petersburg, 1868.

Zigno, A. de. Annotazioni Paleontologiche. 4to. Venezia, 1870.

IV. BOOKS PURCHASED FOR THE LIBRARY.

Berendt, G. Geologie des Kurischen Haffes und seiner Umgebung. 4to. Königsberg, 1869.

Blanford, W. T. Observations on the Geology and Palæontology of Abyssinia, made during the progress of the British Expedition to that country in 1867–68. 8vo. London, 1870.

Dechen, H. von. Geologischer Karte von Deutschland. 1870.

Engelhardt, H. Flora der Braunkohlenformation im Königreich Sachsen. 8vo, and Atlas. Leipzig, 1870.

Hochstetter, F. von, and A. Bisching. Leitfaden der beschreibenden Krystallographie. 8vo. Vienna, 1868.

Issel, A. Malacologia del Mare Rosso. 8vo. Pisa, 1869.

Kenngott, A. Elemente der Petrographie, zum Gebrauche bei Vorlesungen und zum Selbststudium. 8vo. Leipzig, 1868.

Mayer, Charles. Catalogue systématique et descriptif des fossiles des Terrains Tertiaires qui se trouvent au Musée Fédéral de Zurich. 4e Cahier. 8vo. Zurich, 1870.

Oppel, A. Paläontologischen Mittheilungen aus dem Museum des königl. bayer. Staates. 8vo. Stuttgart, 1869.

Pictet, F. J. Matériaux pour la Paléontologie Suisse. Série V. Livr. 7 & 8.

Reeve, L. Conchologia Iconica. Monographs of *Anodon*, *Aplysia*, *Atys*, *Cucullæa*, *Castalia*, *Hyria*, *Pleurobranchus*, *Scutus*, *Tellina*, and *Tugalva*.

Schimper, W. P. Traité de Paléontologie Végétale. Tome II. Part 1. 8vo, with folio Atlas. Paris, 1870.

Veith, H. Deutsches Bergwörterbuch mit Belegen. Erste Hälfte. 8vo. Breslau, 1870.

Zirkel, F. Untersuchungen über die mikroskopische Zusammensetzung und Structur der Basaltgesteine. 8vo. Bonn, 1870.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

---

1. *The* Tertiary Flora *of* Radoboj. By Prof. C. von Ettingshausen.

[Proc. Imp. Geol. Inst. Vienna, May 19, 1870.]

At present the Tertiary Flora of Radoboj is known to include 295 species, which occur in six localities: 9 of these are marine forms (7 Algæ and 2 Naiadeæ); 6 are freshwater (1 *Chara*, 1 *Salvinia*, 1 *Potamogeton*, 1 *Halorhagæa*, and 2 *Typhaceæ*); and 5 are palustrine (2 *Equiseta*, 1 *Juncus*, 1 *Ledum*, and 1 *Andromeda*). Among the terrestrial plants a valley-vegetation of decidedly tropical character is represented by the remains of Palms, Artocarpeæ, species of *Ficus*, Apocynaceæ, Sapotaceæ, Ebenaceæ, Bombaceæ, *Engelhardtiæ*, Combretaceæ, and Melastomaceæ; a mountain-vegetation by the genera *Pinus*, *Betula*, *Fagus*, *Ostrya*, *Carpinus*, *Ulmus*, *Populus* and *Clematis*; and an intermediate flora of subtropical and warm temperate type by a few Laurineæ, Magnoliaceæ, Styraceæ, Oleaceæ, Celastrineæ, Ilicineæ, Anacardiaceæ, and Rhamnaceæ. On the whole the flora of Radoboj is not coëval with that of the Aquitanian Browncoal-formation, as supposed by Prof. Unger, but belongs to a higher geological horizon, and presents a striking resemblance to the flora of Priesen, near Bilin (N. Bohemia). [Count M.]

2. *On the* Fauna *of the* Culm *and* Carboniferous Limestone *of* Lower Silesia. By Dr. E. Tietze.

[Proc. Imp. Geol. Inst. Vienna, April 25, 1870.]

The only trace of vertebrate animals from these deposits is a tooth of *Ctenoptychius* found at Altwasser. The trilobites are represented by *Phillipsia derbyensis*, Mart., *P. gemmulifera*, Phil., and some other species of this genus. Some isolated pygidia must have belonged to individuals of larger size than those generally met with in the Carboniferous Limestone. Small *Cypridinæ* occur at Rothwaltersdorf.

The most remarkable Cephalopoda are *Goniatites crenistria*, Phil., *G. mixolobus*, Phil., *Orthoceras scalare*, Goldf., and *O. striolatum*, v. Mey., which occur in Hesse, Nassau, Westphalia, the Harz, Belgium, England, and Ireland, and thus serve as a strong palæontological proof of the contemporaneity of the two types of the inferior Carboniferous formation, the Culm and the Mountain-Limestone. The first and third of these species have likewise been met with in the Culm of Moravia. The presence of *Orthoceras giganteum*, Sow. (a form with a large subcylindrical shell and a broad slightly excentric siphon, spherically inflated in each chamber), has been clearly ascertained; this species has hitherto been found only in the typical Carboniferous Limestone of Belgium, England, and Ireland; its ocrence in Lower Silesia is rare. Some forms related to *Cyrtoceras Gesneri* (a Belgian and English species) occur; and F. Römer has described specimens of *Nautilus bilobatus*, Sow., a species previously found only in England and Ireland.

The Pteropoda are represented by a species of *Conularia*. Among the Heteropoda are *Bellerophon tenuifascia*, Sow., *B. hiulcus*, Mart., *B. Witryanus*, Kon., and *B. decussatus*, Flem. The first of these species has been found in the Carboniferous Limestone of Belgium, England, Ireland, Ratingen near Düsseldorf, and Tennessee. The most abundant Gasteropoda are *Euomphalus catillus*, Mart., and *E. Dionysii*, Montf., both widely distributed forms, and *Cirrus spiralis*, Phil. Of the same class we have also *Chemnitzia Lefebvrei*, Leveillé, *Littorina biserialis*, Kon., *Buccinum imbricatum*, Phil., *Pleurotomaria canaliculata*, M'Coy, *P. virgulata*, Kon., *Murchisonia Verneuiliana*, Kon., *M. angulosa*, Phil., and *M. gracilis*, Goldf.

The Lamellibranchiata include a considerable number of new forms; they are particularly characterized by the presence of numerous Pectinidæ, as in the Irish Carboniferous limestone; next to these come a number of forms allied to *Cypricardia*, and to the genus usually known as *Sanguinolites*. *Pecten Phillipsii*, Goldf. (described by M'Coy from the Irish Carboniferous limestone under the name of *P. Sowerbyi*), is especially abundant. Other species of the same group noticed by the author are *Pecten Ottonis*, Goldf., *P. ellipticus*, Phil., *P. granulosus*, Phil., and *P. granosus*, Sow. Other Lamellibranchiata mentioned are *Avicula lepida*, Goldf., *Nucula clavata*, M'Coy, *Pinna spatula*, M'Coy, *Corbula senilis*, Phil., *Sanguinolites variabilis*, M'Coy, *Cypricardia rhombea*, Phil., *C. semisulcata*, Sow., *Cardinia subparallela*, Portl. (an Irish species also obtained by Kaiserling from Petschora-land, and by Dames from the Devonian of Rittberg), *Arca prisca*, Goldf., and *Cucullæa tenuistria*, M'Coy. *Conocardia* are very rare; the author has obtained only a few small specimens of the common *C. aliforme*, Sow. *Allorisma sulcatum*, Phil., a characteristic species of the Carboniferous Limestone of England and Russia is not unfrequent; and *A. regulare*, King, has been detected. *Posidonomya Becheri*, Bronn, one of the most characteristic fossils of the true Culm in Nassau, Westphalia, the Harz, Moravia, and England, was met with only at Rothwaltersdorf.

The Brachiopoda, as usual in the Carboniferous Limestone, are the most abundantly represented class, the genera *Productus* and *Spirifer* being especially rich. The author mentions as abundant species, *Spirifer striatus*, Mart., *S. rotundatus*, Mart., *S. glaber*, Mart., *S. lineatus*, Mart., *Spirigera Roissyi*, Leveillé, *S. planosulcata* (*expansa*), Phil., *Chonetes papilionacea*, Phil., *Productus giganteus*, Mart., *P. latissimus*, Sow., *P. longispinus*, Sow., *P. pustulosus*, Phil., *P. punctatus*, Mart., *P. fimbriatus*, Sow., *P. sublævis*, Kon., and *P. mesolobus*, Phil. Other species noticed are *Lingula mytiloides*, Sow., *Orbicula concentrica*, Kon., *O. nitida*, Phil., *Rhynchonella pleurodon*, Phil., *R. pugnus*, Mart., and *R. papyracea*, A. Röm. A few true *Terebratulæ* occur rarely. The only Bryozoa detected are a few badly preserved *Fenestellæ*.

The remains of Echinodermata include an Echinide described by Kunth some years ago, fragments of *Poteriocrinus*, and *Cyathocrinus macrocheirus*, M'Coy. *Lithostrotion junceum* and *Cyathophyllum Murchisoni* are the most abundant corals. A *Receptaculites*, nearly allied to the Upper Devonian *R. neptuni* occurs. Pentremites are wanting.

The palæontological character of these limestones, especially the abundance and diversity of their Brachiopod fauna, indicates that their place is in the lower horizon of the Carboniferous formation. Possibly certain black shales at the upper boundary of the Culm, which still require to be further investigated, may correspond to the middle horizon of the Mountain-Limestone. They contain vegetable remains and *Goniatites mixolobus*; but *Spirifer mosquensis*, a characteristic form of the middle horizon, has not yet been found in them. As in all places where the productive coal-measures appear above the Mountain-Limestone, the *Fusulina*-beds are wanting. The limestones of Rothwaltersdorf, Altwasser, &c., containing Trilobites, Gasteropods, Cephalopods, and Bivalves, seem to represent a higher horizon than those of Neudorf-Silberberg, of which the fauna consists almost exclusively of Brachiopods; but the difference can only be of local importance, as *Productus giganteus* and *P. latissimus* are found in both.

As far as Lower Silesia is concerned, the notion that the Mountain-Limestone is the marine, and the Culm the lacustrine, phase of the Lower Carboniferous formation, is contradicted by the facts. The genuine Carboniferous Limestones and those of Neudorf-Silberberg are concordant deposits in the Grauwackes with vegetable remains. In accordance with the above-mentioned supposition the deposits must have been at first lacustrine, then decidedly marine, then again lacustrine; and such alternations as these could only have been caused by changes of level which must have disturbed the conformity of the stratification. But the plant-bearing Grauwackes have a strongly conglomerate character, especially below—a condition which indicates violent motion of the waters; whilst the localities in which truly marine forms are most abundant have the character of being deposited as a fine argillaceo-calcareous mud. The presence of Brachiopoda and of pelagic Cephalopoda excludes the notion of

marshy deposits. In this respect the slates of Rothwaltersdorf, which constitute a lenticular intercalary deposit in the upper Grauwackes of the Culm, are particularly interesting from their combination of typical Culm fossils, such as *Posidonomya Becheri*, *Calamites transitionis*, *Cyclopteris polymorpha*, *C. dissecta* and other plants, with fossils of the typical Carboniferous limestone. Vegetable remains may certainly be transported from dry land or fresh waters into marine deposits, but not such an abundance of decidedly marine forms into fresh- or brackish-water deposits. The presence of *Posidonomya Becheri* at Rothwaltersdorf, and at no other locality, may be accidental; but as it is always found associated with remains of plants, it is allowable to suppose that it is a freshwater form carried into the sea with those plant-remains. The Culm, with its conglomerates and micaceous sandstones, is a coast formation; and the coast on which it was deposited was strongly acted upon by the waves, whilst the finer mud was thrown down in the quieter parts.

[Count M.]

3. Geology *of the* Odenwald (Environs *of* Heidelberg). By Prof. M. N. Benecke.

[Proc. Imp. Geol. Inst. Vienna, April 5, 1870.]

The Granites and Quartz-porphyries of this district are immediately overlain by Dyas deposits (which have but a small extent both vertically and horizontally), partly Old Red Sandstone Conglomerates and partly Marls, Dolomite, and iron-ores, with remains of *Schizodus obscurus*, representing the "Zechstein." The greater portion of the district is occupied by Triassic deposits, of which the Bunter Sandstone is above 1000 feet in thickness, and has furnished the materials for the most conspicuous buildings of this region (such as the Castle of Heidelberg, the cathedrals of Spires and Worms, &c.). The Muschelkalk presents an interesting form intermediate between those of Franconia, Thuringia, and Swabia. Jurassic deposits occur at the surface only in the basin of Langenbrücken, where the Lias and Inferior Dogger are recognized. Tertiary, diluvial, and alluvial deposits are of quite local occurrence. [Count M.]

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

June 22, 1870.

Horace Pearce, Esq., 21 Hogley Road, Stourbridge, and Samuel Spruce, Esq., of Tamworth, were elected Fellows of the Society.

The following communications were read:—

1. *Notes on the* Lower portion *of the* Green Slates *and* Porphyries *of the* Lake-district *between* Ulleswater *and* Keswick. By Henry Alleyne Nicholson, M.D., D.Sc., M.A., F.R.S.E., F.G.S., &c., Lecturer on Natural History in the Medical School of Edinburgh.

Overlying the Skiddaw slates of the Lake-district and underlying the Coniston limestone is a great series of rocks which are mostly of igneous origin, and were originally named by Prof. Sedgwick the "Green Slates and Porphyries." These rocks consist essentially of stratified felspathic ashes associated with sheets of contemporaneous trap. The ash-beds are mostly cleaved, and they constitute the well-known "green slates" of Cumberland and Westmoreland, whilst the traps are often porphyritic. The origin, therefore, of the name proposed by Prof. Sedgwick is obvious; but there are many reasons why some local name would be preferable. Near the summit of the group is a band containing Caradoc fossils, so that the age of this portion of the series is unequivocal; but no organic remains have ever been detected as yet in the lower portion of the green slates, so that the exact age of this is somewhat uncertain. The entire series of the green slates and porphyries is exhibited over a very extensive superficial area, comprising the central portion of the Lake-district proper, and extending about twenty-five miles along the strike, from E.N.E. to W.S.W., and about thirteen miles in the direction of the dip, from N.N.W. to S.S.E. So much repetition, however, takes place, in consequence of folding and of faults, that it is very questionable if the entire

thickness of the series is more than some 5000 or 6000 feet, though it doubtless varies considerably in different parts of this area.

It is the object of this communication to describe shortly some of the sections in the lower portion of the series of the green slates, as indicating the general lithology of the inferior division of the group. For this purpose I shall confine myself chiefly to the sections which are exhibited between Ulleswater and Derwentwater.

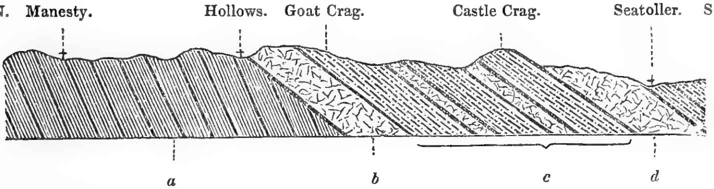
I. *Lower portion of the Green Slates and Porphyries in Borrowdale.*

The whole of the western side of Derwentwater, to the south of the little wooded hill called Rosetrees, is composed of the Skiddaw slates, which dip persistently to the S.S.E., at angles of from 40° to 60°, through Cat Bells, Barrow Side, Maiden Moor, and Narrow Moor, to about a mile to the S.S.E. of Manesty, near a farm-house called the Hollows (fig 1). The Skiddaw slates also form the flat ground at the head of the lake, extending as far south as the village of Grange, and occupying a narrow strip of ground on the western side of the river Derwent. The Skiddaw slates are succeeded to the south by the lowest member of the green-slate series, which is well exhibited in the northern end of Low Scawdel, to the east of the Derwent, and in Grange Fell on the west. It is a massive, dark green, compact, and fine-grained felspathic trap, in places rudely columnar, and exhibiting no distinct crystals of any kind. This trap is directly overlain by a great band of slates and breccias, which have been worked on both sides of the river in various places, and which form Goat Crag, Castle Crag, and the southern end of Grange Fell. The largest quarries are a little to the north of the Bowder Stone. Wherever they have been worked these slaty beds are seen really to be a cleaved felspathic breccia, of which some beds are so fine-grained as to lose their brecciated nature; whilst others consist of numerous angular fragments, from a quarter of an inch in diameter upwards, imbedded in a light-green felspathic matrix. The fragments in the breccia are mostly of felspathic ash or trap; but many are very like pieces of Skiddaw slate. Subordinate to the bands of slate and breccia are some minor beds of trap, one of which near the Bowder Stone exhibits numerous small veins of epidote. The highest beds of the whole of this slaty series are amygdaloidal ashes, the cavities of which are mostly filled with quartz.

A similar sequence of rocks is exhibited a few miles to the S.W., in the valley of Gatesgarth Beck, which flows into the head of Buttermere. In proceeding from the head of Buttermere into Borrowdale, by way of Buttermere Hawse, the lower portion of the Gatesgarth valley is found to be occupied by the Skiddaw slates, which dip S.S.E., at from 50° to 60°, forming Buttermere Fell and the N.W. end of Honister Crag. At Dale Head the Skiddaw slates are succeeded by the lowest member of the green slates, in the form of a fine-grained dark-green felspathic trap, rudely bedded, and crossed at one point by a nearly vertical dyke of intrusive greenstone. This is overlain by a great series of cleaved felspathic ashes, amyg-

daloids, and breccias, with subordinate bands of trap. The lowest beds of this series are cleaved felspathic ashes, partly brecciated; these are followed by a very beautiful amygdaloid, composed of a fine-grained green felspathic base, with large oval or rounded cavities, mostly filled with crystalline carbonate of lime, but often empty, and exhibiting a fine vitreous glaze. Above this amygdaloid come ashes and breccias again, of which the ashy bands form a very good fine-grained green slate, which is largely worked at Dale Head and in the celebrated quarries of Honister Crag. The breccias are cleaved and also form a slate, which is sometimes green, sometimes purple in colour. Of the subordinate trappean bands one of the most noticeable is a fine purple felstone, containing numerous large crystals of greenish felspar. This great slaty series extends as far as the summit of Borrowdale Hawse, and it is the unquestionable equivalent of the breccias and slates which are worked at the entrance of Borrowdale. Succeeding these in the S.E. flanks of Seatoller Fell is a massive trap, sometimes fine-grained, sometimes porphyritic, and very well exposed in the course of Horse Gill. At Seatoller itself brecciated ashy beds again succeed to this trap (fig. 1).

Fig. 1.—*Section from Manesty, on the west side of Derwentwater, to Seatoller, in Borrowdale.* Distance four miles.



a. Skiddaw Slates.
b. Felspathic trap, forming the base of the Green-slate series.
c. Great series of ashes, breccias, and amygdaloids, with some intercalated bands of trap.
d. Trap.

II. *Lower portion of the Green-slate Series on the east side of Borrowdale.*

On the eastern side of Derwentwater the relations of the Green Slates and Porphyries in their lower portion are by no means so clear as in Borrowdale and in the Gatesgarth Valley, there being much folding and apparently several faults.

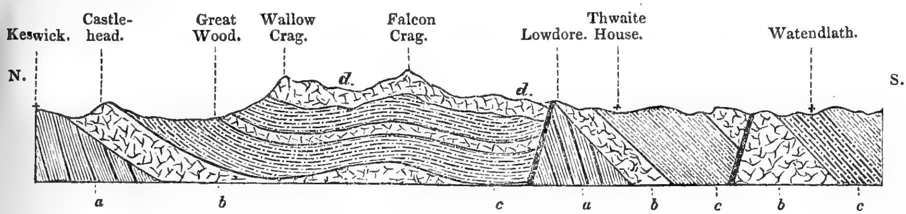
At Keswick itself the Skiddaw Slates are seen in the bed of the Greta, dipping S.S.E. at high angles (fig 2). To the south of this, in a little wooded hill called Castle Head, there is a massive greenish grey felspathic trap, containing a good deal of hornblende. Proceeding along the eastern side of Derwentwater, the next rock which is seen *in situ* is a massive red breccia, which occurs in Great Wood at the base of Wallow Crag. This red breccia consists of a dark red matrix, containing numerous angular fragments of felspathic ash

and trap. It is an extremely hard, compact rock, and is apparently altogether devoid of cleavage. The red breccia is surmounted by a series of green breccias, ashy beds, amygdaloids, and a few trappean bands, which form the mass of Wallow Crag, the whole being overlain by a fine purple or green porphyritic trap. To the south of Wallow Crag a synclinal fold appears to occur; and a similar series of breccias and ashes is found in the lower portion of Falcon Crag, near Barrow, dipping northwards at very low angles (about 10°). Forming the summit of the Falcon Crag and the western end of Castlerigg Fell, is a felspathic trap which is nearly horizontal, or has a slight northerly inclination, and appears to be the same as the trap on the summit of Wallow Crag. Still further to the south, between Ashness and Watendlath Beck, an anticlinal fold is formed, and the same strata are again exhibited. Here the lower red breccias are seen nearly horizontal and overlain by the green breccias, both folding over ultimately towards the south, but at extremely low angles. The bedding is very well displayed, and the breccias continue to be visible till Watendlath Beck is reached. Here a fault seems to come on, running in an E.N.E. and W.S.W. direction, across the southern end of Ashness Fell. The evidence of this fault is found in the occurrence again of the lower members of the Green-slate series in the lower part of the Watendlath valley. Between Lowdore Inn and the Waterfall are seen the Skiddaw Slates, a good deal twisted and broken. These are overlain by a massive dark-green felspathic trap, which forms the northern end of Brown Dodd, and over which Watendlath Beck is precipitated to form Lowdore Waterfall. This trap continues up the stream for some distance; and is succeeded at Thwaite House by a series of cleaved green breccias, with some trappean beds, the former having a vertical cleavage, and the whole dipping S.S.E. at 20°. With the higher part of the Watendlath Beck I am not well acquainted; but at the village of Watendlath, about a mile and a half above Lowdore, there comes on again a great series of slates and breccias, also with a southerly dip, so that it is most probable that a second E.N.E. and W.S.W. fault produces another repetition of the same beds.

The probable relations of the lower members of the Green-slate series in this intricate district are shown in the subjoined sketch section from Keswick to Watendlath (fig. 2). Whether this is strictly correct in all particulars or not, it appears quite certain that the following relationships exist between the beds in Borrowdale and on the east side of Derwentwater:—1. The trap of Castle Head is the lowest member of the series, and is the same bed which occurs at Lowdore, this in turn being identical with the trap of Grange Fell and the Hollows in Borrowdale, and of Dale Head in the Gatesgarth valley. 2. The massive red and green breccias which are seen in Wallow Crag, Falcon Crag, at Barrow Waterfall, and at Ashness are the equivalent of the great slate-band of Borrowdale and Honister. The slaty cleavage is only partially developed, and is sometimes absent; but in other respects the rocks are the same, and they correspond to each other in stratigraphical position. 3. The trap

which forms the summit of Wallow Crag and Falcon Crag corresponds to that which succeeds the great slate-band of Honister, in Seatoller Fell. 4. The slates and breccias which occur in the lower part of the Watendlath valley, and again at Watendlath village, are undoubtedly the equivalents of the Borrowdale Slates. At Watendlath village this band appears to be shifted considerably to the south, since it can be traced across the southern end of Brund Fell nearly as far as Rosthwaite, in Borrowdale; and the prolongation of this line of strike would carry it out to Seatoller, whereas the slates on the western side of Borrowdale do not extend further to the south than Castle Crag, about a mile to the north of Seatoller.

Fig. 2.—*Section from Keswick to Watendlath.* Distance four miles.



a. Skiddaw Slates.
b. Lowest trap of the Green-slate series.
c. Ashes, breccias, and amygdaloids, with some trappean beds.
d. Second trap of the Green-slate series.

III. *Lower portion of the Green-slate Series between Keswick and the Vale of St. John.*

Crossing the north and south ridge which divides the depression in which Derwentwater is situated from the parallel valley of Naddle Beck, the base of the Green-slate series is seen close to the farm of Rake Foot in the form of a greenish grey felspathic trap, which is continuous to the west with the trap of Castle Head, and is traceable eastwards into the valley of Naddle Beck. Here, close to a farm called Dale-bottom, it is seen resting upon the Skiddaw Slates in the course of a small stream which flows down from a hill known as the Pike. In both places this lowest trap is overlain by a series of red and green breccias, which, however, are of considerably less thickness than further to the west in Wallow Crag. Intercalated in these breccias in the Pike is a large mass of felspathic trap, sometimes porphyritic; and this is succeeded by an exceedingly fine amygdaloid, the cavities of which are sometimes of very large size, and are filled either with calc-spar or with agatescent quartz. The strata which form the Pike are, thus, essentially the same as those which occur in Wallow Crag; but the breccias have to a great extent thinned out in their passage eastwards.

Southwards, the strata which form the Pike are succeeded by a great series of bedded traps with a few ashy beds, the former greatly

predominating. These beds form the whole of Brackenriggs Fell as far as Shoulthwaite Gill. They vary much in character, being sometimes compact and fine-grained, at other times highly porphyritic. In places the bedding is well shown, the dip being S.S.E. at 25° to 30°. At Shoulthwaite a synclinal fold occurs; and in proceeding up Shoulthwaite Gill we have a repetition of these bedded traps, with a few ashy and brecciated beds, the sheets of trap dipping northwards at angles of from 20° to 30°. This northerly inclination is particularly well exhibited in the flanks of the Benn and Low Bank, on the eastern side of the valley, and of Castlerigg Fell and Bleabery Fell, on the western side.

IV. *Lower portion of the Green-slate Series in the Vale of St. John.*

The north and south ridge which separates the valleys of Naddle Beck and the vale of St. John, exhibits a very clear section of the lower portion of the Green-slate series (fig. 3). The extreme northern end of this ridge, known as Low Rigg, is entirely composed of the intrusive syenite which I have described as occupying the mouth of the vale of St. John (Quart. Journ. Geol. Soc. vol. xxv. p. 435). Southwards the syenite is succeeded at the Chapel of St. John by a compact, fine-grained, dark-green, felspathic trap, which forms the northern end of Naddle Fell, and is well seen above the farm of Rake How. This trap is the lowest member of the Green-slate series; and it forms a tabular mass of considerable thickness, which dips S.S.E. at about 30°. It is not, however, succeeded by ashes and breccias, as in Borrowdale and at Keswick; but it is overlain by a great series of felspathic traps and greenstones, which form the whole of Naddle Fell and High Rigg, on the western side of the Vale of St. John. Occasionally there occur thin bands of ash, as at Sosgill and Low Bridge End; and at this latter place the ash is highly amygdaloidal. This succession of bedded traps is exceedingly well displayed along the flanks of Naddle Fell, forming a series of oblique terraces, which dip S.S.E. at about 30°; and a similar sequence of beds, though not in so marked a form, appears to obtain in Wanthwaite Crag, on the eastern side of the valley. The traps of Naddle Fell vary a good deal in lithological characters, being usually more or less porphyritic and containing a considerable quantity of hornblende. At the southern end of Naddle Fell there is a highly porphyritic trap, which closely resembles some of the beds seen near Aira Force; and this is overlain in Warren Crag by a great mass of greenstone, which seems to be a continuation of the celebrated Castle Crag, on the eastern side of the valley. If this is the case, however, it is shifted to the north by a fault. The whole series of traps is succeeded close to Smeathwaite Bridge by bedded felspathic ashes, which dip S.S.E. at 45°. Continuing the section from Smeathwaite Bridge down the western side of Thirlmere, we cross again a similar series of traps and greenstones to those which occur in the Vale of St. John, the repetition being doubtless due to the occurrence of a synclinal, though it is extremely difficult to make out any dips.

Hardly any traces of ash-beds can be discovered; and the series here consists of a succession of traps, most of which are highly porphyritic.

The general sequence of beds in the Vale of St. John is indicated in the annexed section (fig. 3), from which it will be seen that the great slate-band of Honister and Borrowdale has now almost completely thinned out, its place being taken by bedded traps.

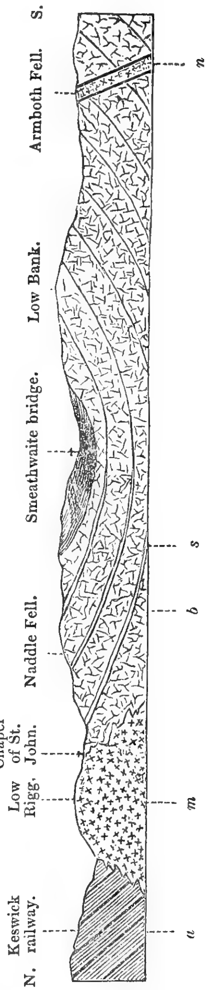


Fig. 3.—*Section from Threlkeld Station to Armboth.* Distance five miles.

a. Skiddaw Slates. *b.* Lowest trap of the Green-slate series. *s.* Place of the Borrowdale Slates. *m.* Syenite of the Vale of St. John. *n.* Felstone-dyke near Armboth.

V. *Lower portion of the Green-slate Series in Matterdale.*

Eastwards from the Vale of St. John the lower beds of the Green-slate series maintain much the same characters, the absence of any well-marked and conspicuous band of slates still holding good. No continuous and complete section, however, can be obtained.

If we follow up a stream known as Mosedale Beck, which divides Threlkeld Common from Flaska Moor, towards the head of the stream the Skiddaw Slates are seen to be succeeded to the south by a mass of felspathic greenstone, which forms the striking eminence known as Wolf Crags, and which constitutes the base of the Green-slate series. Still further to the west, in the course of Troutbeck Beck, about a mile to the south of Troutbeck village, the base of the Green Slates is found to succeed the Skiddaw Slates in the form of a greenish-grey felspathic trap, in part very ashy, and decomposing very readily. This is followed by ash-beds of small thickness; and these in turn are surmounted by a great mass of porphyritic greenstone. Between this point and Ulleswater no beds are exposed except detached masses of trap, the best section of which is afforded by Aira Beck. From Thorneythwaite by Dockwray, and in the course of Aira Beck itself, no slates or ash-beds are visible; but there is a constant succession of traps. These vary much in character, but are mostly highly porphyritic, containing numerous crystals of white or orange felspar, and generally a good deal of hornblende. Before reaching Ulleswater, however, on the southern

side of Glencoin Park, there comes on a well-marked band of slates and ashes, the inclination of which appears to be northwards. This would render it probable that the synclinal axis which crosses the vale of St. John is prolonged eastwards as far as Dockwray; but there are no signs of these slates to the north of Dockwray.

VI. *Lower portion of the Green-slate Series in Eycott Hill.*

Leaving the main area of the Green Slates and Porphyries for a moment, an excellent exhibition of the lower part of this group is afforded in a rugged hill, known as Eycott Hill, about a mile and a half to the north of Troutbeck Station. North of Troutbeck Station for some distance the country is undulating and moory, and the stream-sections exhibit nothing but drift. There can be no question, however, that this area is occupied by the Skiddaw Slates, since these are seen close to the Station, striking in this direction, and dipping N.N.W. at 50°. When Greenah Moss is reached, a low range of craggy hills commences, trending N.W. and S.E. These are composed of green slates and porphyries, which begin near Greenah Crag, rise in the centre into Eycott Hill (1131 feet), and sink again towards Murrah.

The general structure of this range is well exhibited in a little stream which flows down from Eycott Hill, and which displays the following sequence of beds in ascending order:—

1. Bedded felspathic ashes, 3 or 4 feet in thickness.
2. A porphyritic trap, containing small crystals of felspar, about 20 feet.
3. Bedded felspathic ashes (about 15 feet), dipping N.E. at 30°.
4. A magnificent bedded amygdaloidal and porphyritic trap, sometimes rudely columnar. The base of this beautiful rock is composed of fine-grained dark-green matrix, with numerous specks of hornblende. Scattered through this are very numerous and large crystals of a light-green or olive-coloured felspar, the length of which varies from $\frac{1}{8}$ up to as much as $\frac{1}{2}$ an inch. The whole rock exhibits also a considerable number of amygdaloidal cavities, some of which are filled with calc-spar, whilst others contain silica in a form nearly approaching to opal. Some of the larger vesicles are filled centrally with calc-spar, with an outer covering of chalcedony.
5. Compact felspathic trap, dark green in colour, and containing many long crystals of glassy felspar.
6. Ashy beds, in part conglomeratic, with pebbles of trap.
7. Amygdaloidal ashes, the cavities of which are sinuous and drawn out, and are filled with chalcedony, calc-spar, or some hornblendic mineral. The matrix of these beds appears to contain a small quantity of carbonate of lime, as it effervesces slightly with acids.
8. A series of bedded felspathic traps, usually containing numerous minute crystals of felspar.

The further sequence of the rocks in this section is now hidden by the Scar Limestone, which comes on close to the road between Berrier and Murrah. The entire length of the section is little short

of a mile; and if we take 30° as the average angle of dip, this would give a thickness of probably about 2000 feet, making some deduction for possible flexures. Throughout this thickness, however, there is no well-marked band of slate, and in fact nothing of a slaty nature, with the exception of the small ashy beds above alluded to. The absence, therefore, of any horizon equivalent to the great slate-band of Borrowdale is worthy of notice; and the same obtains further to the N.W. in the Caldbeck Fells, of which, indeed, Eycott Hill is only a continuation.

VII. *Lower portion of the Green-slate Series between Ulleswater and Haweswater.*

The general direction of Ulleswater is N.E. and S.W., pretty nearly corresponding with the strike of the Silurian rocks of the district; and the lower reach, at any rate, is placed in a depression which coincides with a line either of folding or of faulting. This is shown by the occurrence of a small area of Skiddaw Slates immediately to to the south-east of Pooley, the occurrence of these strata here being most probably due to an E.N.E. and W.S.W. fault, but being possibly caused by an anticlinal fold. These, in turn, are followed to the south-east by the lower members of the Green-slate series.

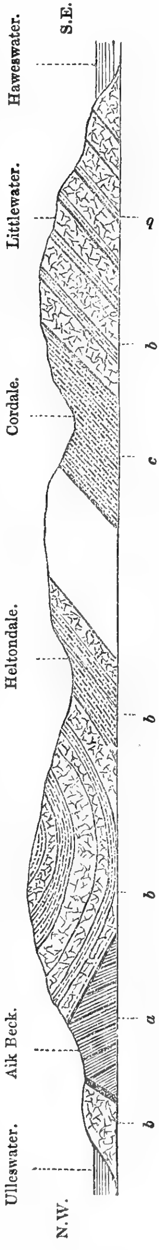
In ascending Aik-beck (or Eggbeck), a small stream which flows into Ulleswater from the south, close to Pooley, the first rocks exposed *in situ* are the upper shaly beds of the Skiddaw Slates, somewhat contorted, but having a general dip to the S.S.E. at high angles (fig. 4), The Skiddaw Slates are succeeded by bedded felspathic ashes, not more than a few feet in thickness, which graduate upwards into a felspathic trap. This trap, when unweathered, consists of a light greenish-grey felspathic matrix, containing minute specks of hornblende and scattered crystals of felspar. When weathered it is of a brownish-green colour with orange spots. Beds of ashes, with a band of grey felspathic trap, succeed, and then a series of coarse felspathic ashes, dipping S.S.E. at 40°. These ashes, with some intercalated trappean bands, continue up the stream for a considerable distance, when they are overlain by a thick mass of felspathic trap of a greenish-grey colour. This is, in turn, surmounted by an ashy conglomerate, composed of a dark-green matrix with numerous yellow spots, enclosing many small pebbles, apparently composed of trap. This conglomeratic ash passes into beds of coarse ash, which continue up the stream as far as any rocks are exposed.

Beyond the summit of the watershed there are few rock-exposures; but Arthur's Pike, an eminence about half a mile to the south-west, is found to consist of a cleaved felspathic breccia, of a green colour, very similar in every respect to the Borrowdale Slates.

Whitestone Moor, to the south of this, exhibits no rock *in situ*; but in the upper part of Heltondale Beck are seen felspathic ashes and traps, apparently dipping northwards, and very similar to the beds which occupy the higher part of Aik Beck. It would appear, therefore, that there is a synclinal axis crossing Whitestone Moor in an E.N.E. and W.S.W. direction.

About a mile to the south of Heltondale Beck, and running parallel with it, is a second valley, called Cordale, the intervening ridge showing no rock-exposure. Both sides of Cordale are occupied by slaty beds, which strike E.N.E. and W.S.W., and have an apparent dip to the N.N.W. at 55°. These beds have been pretty largely worked for slate in the upper part of Cordale, and they consist partly of ordinary green slate and partly of a cleaved purple breccia, very similar to that worked in Borrowdale in all except its colour. There can be little doubt that these Cordale Slates, though not clearly represented in Aik Beck, are really the lowest slate-band in the series, and that they are a repetition to the south of the great slate-band which is worked at the head of Ulleswater, near Patterdale, and which is feebly represented in Arthur's Pike.

Fig. 4.—*Section from Ulleswater to Haweswater.* Distance six miles.



a. Skiddaw Slates. *b, b.* Traps and ashes of the Green-slate series. *c.* Slate-band of Cordale.

To the south of Cordale come on coarse felspathic ashes, still dipping northwards; and these are again followed by a varied and thick series of bedded traps and ashes, which occupy the hilly ground round Littlewater, directly to the north of the foot of Haweswater. In this region the traps and ash-beds succeed one another rapidly, and vary greatly in lithological characters, all, however, dipping N.N.W. The ashes are sometimes fine-grained, sometimes brecciated, and sometimes amygdaloidal; the traps are green or purple in colour, and are mostly highly porphyritic.

VIII. *Lower portion of the Green-slate Series in the neighbourhood of Shap.*

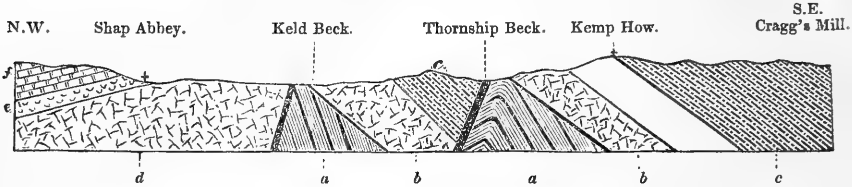
Owing either to folding or, more probably, to faults, in one instance at any rate, the Skiddaw Slates, and with them the lower beds of the Green Slates and Porphyries, are exposed in three distinct areas to the south-east of Haweswater. The best section, as exhibiting the relations of two of these areas, is to be found in the river Lowther and its tributaries, to the west and south-west of Shap (fig. 5). Commencing at Shap Abbey, there is shown in the bed of the stream, just above the Abbey Mill, an earthy trap with some felspathic ashes, both deeply reddened by the overlying conglomerates of Old Red Sand-

stone. Above this point the stream cuts, for about a quarter of a mile, through glacial drift containing many blocks of trap and pieces of Skiddaw Slate. Here a little stream flows into the Lowther from the west, and exhibits the Skiddaw Slates a good deal contorted, but dipping on the whole S.S.E. These are almost immediately succeeded by a greenish-grey fine-grained felspathic trap, which forms the base of the Green-slate series. This is sometimes slightly hornblendic, and with some coarse ashy-looking beds occupies the ground up to the mouth of Keld Beck, also flowing into the Lowther from the west. Nearly half a mile to the south-east of Keld Beck is a third tributary, called Thornship Beck; but the ground between these two streams is moory, and exhibits only a few scattered bosses of trap. In Thornship Beck, at its head, are seen bedded felspathic ashes, sometimes purple, sometimes green, with veins of quartz, and nodules of bright red jasper, and having intercalated amongst them one or two beds of trap. In the lower part of Thornship Beck the Skiddaw Slates again come on, and have been worked for slate-pencils. Their appearance here would appear to be most probably due to faulting, the dip varying a good deal; but at the quarries there is a small anticlinal. The country to the south-west of Thornship Beck is very moory, and no rocks are seen *in situ* except a small exposure of a greenish-grey felspathic trap at the mouth of Thornship Beck. The termination upwards of the Skiddaw Slates is therefore not seen. The next exposure of rock is at a farm-house called Kemp-how, situated on the Lowther, about half a mile to the south-west of Thornship Beck. Between this point and Cragg's Mill there is a fine section of some of the lower beds of the Green-slate series, consisting entirely of ashes and breccias, all highly cleaved. Some of the ash-beds have the ordinary characters of the "green slates;" others are breccias, in which the included fragments consist entirely of ash; and others are amygdaloidal, containing numerous sinuous vesicles, which are either empty or filled with quartz. The strike of the beds is a good deal deranged, varying from S.S.W. and N.N.E., through E.N.E. and W.S.W., to nearly due W. and E., the cleavage throughout being nearly vertical.

From the position of these beds there can be no doubt of their being the equivalent of the great slate-band of Honister and Borrowdale; and they thus afford a useful guide in mapping this region. They can be traced to the south-west along the northern side of Wet Sleddale, through the higher part of Swindale, across the head of Long Sleddale (in the Gatesgarth Pass), across Kentmere (near the Reservoir), and across the head of Troutbeck; and I have little doubt of their identity with the great band of slates which is worked between Rydal and Grasmere, and again still further to the south-west in Tilberthwaite, and in the Dunnerdale Fells. In all these localities I believe that these slates point to an horizon very close to the base of the whole series of the Green Slates and Porphyries, though not far removed from the southern limits of the great area occupied by this formation.

The general sequence of rocks near Shap, as above described, is shown in the subjoined section (fig. 5).

Fig. 5.—*Section from Shap Abbey to Wet Sleddale.* Distance two miles.



a. Skiddaw Slates.
b. Lowest trap of the Green-slate series.
c. Slates and breccias (=Borrowdale Slates).
d. Trap belonging to the Green-slate series.
e. Conglomerates belonging to the Old Red Sandstone.
f. Base of the Scar-limestone series.

2. *Observations on some* VEGETABLE FOSSILS *from* VICTORIA. By Dr. FERDINAND von MÜLLER and R. BROUGH SMYTH, Esq., F.G.S.

(The publication of this paper is deferred.)

[Abstract.]

Mr. SMYTH stated that the fossils, of which specimens were forwarded by him, were obtained in one of the deep leads at Haddon, near Smythesdale. No leaves have been obtained from the bed, which consists of a greyish-black clay; the fruits and seed-vessels were obtained about 180 feet from the surface, and represent a flora not very dissimilar to that now characterizing some parts of Queensland. The specimens sent include the fruits of a supposed new genus of Coniferæ, described by Dr. von Müller under the name of *Spondylostrobus*. It is most nearly allied to *Solenostrobus*, Bowerbank; but its five valves are not keeled. The columella forms the main body of the fruit; and the seeds are apparently solitary. The species was named *Spondylostrobus Smythii*. The remaining specimens consisted of:—a solitary fruit of a genus of Verbenaceæ; an indehiscent compressed fruit, probably belonging to the proteaceous genus *Helicia*; a nut nearly allied to the preceding; a large, spherical, unilocular, 3-seeded nut with a thick pericarp, perhaps from a Capparidaceous plant; a 5-valved capsule of an unknown genus; and fruit-valves of three other plants, probably belonging to the Sapindaceæ, and perhaps allied to *Cupania*. One of the last may belong to the Meliciaceous genus *Dysoxylon*. Dr. Müller considered that these remains indicate a former flora analogous to that of the existing forest-belt of Eastern Australia.

3. *Note on some* Plesiosaurian Remains *obtained by* J. C. Mansel, Esq., F.G.S., *in* Kimmeridge Bay, Dorset. By J. W. Hulke, Esq., F.R.S., F.G.S.

(Plate XLI.)

These remains form part of the rich series of Enaliosaurian fossils obtained from Kimmeridge Bay, by J. C. Mansel, Esq., to whose courtesy I am indebted for the opportunity of bringing them under your notice. They consist of five vertebræ, four of which are nearly entire, with pieces of several ribs, a digital phalanx, and a carpal bone (?), imbedded in two slabs of clay-stone, indicating an undescribed species of *Plesiosaurus,*—and of a large number of associated bones representing another species characterized more particularly by the proportions and peculiar construction of its paddles, which sharply separate it from the typical *Plesiosauri* of the Lias, and show an extremely close affinity with *Pliosaurus.*

Plesiosaurus brachistospondylus (Pl. XLI. figs. 7–9).

The middle dorsal vertebræ (the only ones in Mr. Mansel's collection) of the species for which I propose this name, are characterized by the extreme shortness of the centrum, which in three of the vertebræ lying in one slab has a length, or antero-posterior diameter, of 1 inch only, measured along the outer, non-articular surface. The length of the fourth centrum, in the other slab, is ·3 inch more; but this centrum is a little obliquely distorted by pressure. The breadths (or horizontal transverse diameters) of the centra are respectively 4·6, 4·5, 4·3, 4·4 inches; and their heights (or vertical diameters) are 4, 4, 3·8 inches.

Centrum.	Length. inch.	Height. inches.	Breadth. inches.
No. 1.	1	4	4·6
No. 2.	1	..	4·5
No. 3.	1	4	4·3
No. 4.	1·3	3·8	4·4

		No. 1.	No. 2.
Length of transverse process	upper border	3·1	2·7
	lower border	3·1	2·4

Span between ends of transverse processes 6·7 inches.

Height of neural spine about 3·6 inches.

Height of entire vertebra from lower border of centrum to top of neural spine about 9·4 inches.

These centra are therefore about four and a half times as broad, and nearly four times as high as they are long—proportions which I have not found in any other *Plesiosaurus.* The articular faces are gently swollen near the circumference, and hollow at the middle, where the distance between the two faces in one centrum measures ·7 inch. These proportions and the hollow articular faces

give the centra some resemblance to those of Ichthyosaurian vertebræ, from which, however, they may be at once distinguished by the absence of costal tubercles from the outer surface, and by the circumferential swelling of the articular face. But these vertebræ are sharply differentiated from those of *Ichthyosaurus* by their anchylosed neurapophyses bearing long transverse processes. These are laterally compressed blades directed upwards and outwards from the neural arch. Their outer end is slightly swollen, and cut obliquely, which makes the upper border of the process longer than the lower one, and gives the terminal rib-bearing surface an almost directly outward aspect.

The anterior articular processes spring from the crown of the arch, immediately above the neural canal. Their lower ends meet, and their upper ones are incurved, so that together the two prezygapophyses form about two-thirds of a circle, each half of which looks inwards and embraces the corresponding posterior articular process, the shape of which, and the aspect of its articulating surface, are the counterparts of those of the anterior one. The posterior articular processes spring from the back of the arch just below the root of the neural spine, in a rather higher level than that of the anterior. The neural spines are long and straight.

The ribs have a simple flattened head, separated by a slight constriction from the angle $3\frac{1}{2}$ inches distant, beyond which they sweep outwards and downwards in an even curve. Their upper, convex border is thick, the lower one is thin, and a shallow groove parallel to the upper one channels the surface of the rib.

The digital phalanx had the usual cylindrical figure, with constricted middle of a Plesiosaurian digit-bone. It is 1·5 long, ·9 broad at ends, ·5 broad at middle.

Plesiosaurus Manselii (Pl. XLI. figs. 1–6).

In November 1868 Mr. Mansel kindly sent me for examination a large series of vertebræ, evidently comprising the greater part of the spinal column of a *Plesiosaurus*, with pieces of the two humeri, and several incomplete flat bones, which some years before had been discovered in the cliffs east of Clavell's Tower, in Kimmeridge Bay.

Mr. Mansel informed me that he had himself supervised their exhumation, and that the bones were associated in such a manner as to leave no doubt in his mind that they had all belonged to one individual; and he also mentioned that, under the impression that they were Pliosaurian remains, he had enclosed the four great paddle-bones with carpals and many phalanges in a case of Pliosaurian fossils which he had presented to the British Museum. It was Mr. Mansel's first impression that all the four limb-bones had been enclosed in this case; but the parts actually sent were the nearly complete left femur, the proximal half of the right one, and the distal half of the left humerus. On recently taking to the Museum the proximal halves of the humeri which Mr. Mansel sent me in November 1868 (with the spinal column) one was found to fit exactly the distal fragment of the humerus already in the Museum; and the national collection now contains the nearly perfect femur and left humerus

and the proximal halves of the right femur and humerus, with the smaller paddle-bones, already mentioned, of this *Plesiosaurus*.

Mr. Mansel has recently seen these humeri and femora since their restoration; and he has identified them as the limb-bones which he exhumed together with the spinal column which he sent me. Their general facies, the peculiar texture of their surface, and the correspondence of small pieces of the clay still adhering to them, confirm Mr. Mansel's statement that these limb-bones did belong to the same individual. I may add that there is a close resemblance in these points between the paddle-bones and the large flat bones of the pelvic and breast-girdles. I have entered into these details because, on account of the remarkable construction of the paddles, it is important that their identification with one another and with the spinal column should be as complete as possible.

Spinal Column.—The spinal column is that of a long-necked *Plesiosaurus*. All the early cervical vertebræ have been subjected to lateral pressure, which has flattened the sides of the centra, and reduced their breadth, but increased their height. Throughout the spinal column the neurapophyses have been broken off from the centra, to which they were completely anchylosed; and very few of them have been recovered. The eighty-six vertebræ which have been preserved are distributed as follows. Twenty-seven bear a transverse process low on the side of the centrum, and therefore belong to the front of the neck. Their combined lengths amount to nearly 5 feet; but the original length of this part of the neck was more than this, because several vertebræ behind the axis are certainly wanting, and there is another gap between the 12th and 13th of the series. Twenty-three have the transverse process replaced by a costal pit, higher on the side of the centrum, or they have a transverse process rising from the centrum into the root of the neurapophysis. These, then, are transitional vertebræ between the front of the neck and the trunk, or between the dorsal and caudal segments. I am not acquainted with criteria by which the transitional centra of these regions can be certainly distinguished, the prethoracic and early thoracic from the lumbar ones. The larger ones I have assigned to the lumbar region, because their dimensions accord best with those of the early caudal centra. The united lengths of the transitional vertebræ amount to nearly 4 feet.

Nineteen have the transverse process borne wholly on the neurapophysis, and are reckoned dorsal or mid-trunk vertebræ. Their united lengths give 3 feet 6 inches.

Seventeen are caudals, all but the foremost bearing chevron-facets. Their combined length is 2 feet 6 inches. The united lengths of all the vertebræ make about 15 feet; and taking into account the known large gaps in the neck, and the probability that other vertebræ are also missing, the original length of the spinal column will probably be not overestimated at 17 feet.

The atlas and axis are anchylosed. A shallow vertical groove on their side indicates their original separateness. The anterior articular face of the atlas is a cup with a diameter of about 1·1 in., but

originally somewhat more, as the lip is slightly abraded. A little above its middle there is a small deeper pit. The sutures which marked the original distinctness of its component elements are no longer traceable. The sides or outer surfaces of the conjoined vertebræ are vertical; they bear a low horizontal ridge, separating an upper from a lower shallow depression; and at their junction with the under surface the atlas has a strong lateral tubercle representing a transverse process, which in the axis is a well-developed compressed ridge projecting downwards and backwards. A strong median tubercle projects downwards and forwards from the under surface of the atlas. In front a slight interval of about ·1 inch separates this from the lower margin of the anterior articular surface; and behind it is continued into a narrow median ridge, dividing the under surface of the axis. In a longitudinal direction the under surface of the atlas is slightly convex, and that of the axis is gently concave; while transversely, between the median ridge and the lateral transverse process, this surface of the axis is more positively hollow. The posterior articular face of the axis is deeply hollow at its middle, while its lip is tumid. The neural arches of both these vertebræ are crushed and broken off.

From the first to the thirteenth of the cervical series all the vertebræ are slightly distorted by lateral pressure, by which their vertical diameter has been slightly increased and their horizontal one lessened. All the neural arches are gone. The sides of the centra are nearly plane vertically, but deeply concave horizontally. The suture marking the lowest limit of the neurapophysis is hardly visible, and in many quite undistinguishable. The transverse processes are simple downward-projecting blades attached to the whole length of the side of the centrum, anchylosed to it. A horizontal line above the root of the blade marks its junction with the centrum; and above this line the side of the centrum is deeply hollowed.

In the ninth of the cervical series the distance between the upper limit of the transverse process and the lowest limit of the neurapophysis on the side of the centrum is 1·3 inch, the length, breadth and height of this centrum being respectively 2·1, 2·4, and 2·2 inches. The under surface of the cervical vertebræ is nearly plane transversely, broken by a low median ridge, on each side of which is a hollow pierced by a vascular foramen; while axially it is concave. The articular faces are rather deeply hollowed centrally, and less so peripherally. Their true contour is subcordate, the emargination above corresponding to the neural canal. The neurapophyses arise in the form of thin laminæ from nearly the whole length of the upper surface of the centrum, coming rather closer to the anterior than to the posterior articular surface. In the later vertebræ of the anterior cervical region the laminæ become shorter antero-posteriorly, and stouter. The transverse processes are also stouter and much less compressed here; their transverse section has an oval figure; and their anterior border slants more backwards.

From the twenty-seventh of the cervical series backwards through-

out the rest of the neck, and in the vertebræ referred to the early thoracic segment of the spinal column, no anchylosed transverse process occurs; but the side of the centrum bears a costal pit at a higher level than the line of attachment of the transverse processes in the earlier cervical vertebræ. This pit, when relatively low on the side of the centrum, is a circular or roundly oval hollow, with swollen edges; but as it rises upwards towards the root of the neurapophysis (or descends from it, in the case of the lumbar vertebræ) it becomes elongated vertically, until its vertical diameter in some vertebræ is nearly double the horizontal. With the recession of the transverse process, and later of the costal pit, from near the under surface of the centrum, this surface becomes less flattened, it is more convex transversely, and the narrow median ridge is replaced by a broader swelling. The vascular foramina are in many instances more than two, and they are not regularly placed. All the dorsal vertebræ are more or less mutilated and crushed. The contour of their centrum is more circular than in the other regions, owing to the absence of transverse processes from its outer surface. The articular faces are gently hollow: their contour is a full oval figure, emarginate above at the canal. Some mutilated neural arches severed from their centra have been preserved. The neurapophyses are stout, shorter antero-posteriorly than in the neck. They rake slightly forwards. The transverse processes stand outwards and upwards from the arch. They are strong, horizontally compressed blades, having a stout and straight upper edge, and a thinner concave lower one. Their outer end expands slightly, and it is obliquely cut as in *Plesiosaurus brachistospondylus*. The caudal vertebræ are distinguished by the flatness of the under surface of the centrum, as well as by the chevron-facets. These latter are absent altogether from the largest (first?) caudal; and the second to the fifth of the series have them on the posterior margin only; while the sixth and all those succeeding it have two facets on the anterior, and two on the posterior margin. In the hinder caudals the four chevron-facets enclose a deep hollow. The transverse processes have a conical base projecting horizontally from a prominent tubercle on the side of the centrum, about midway between its under surface and the neurapophysis. Most of them are anchylosed to this tubercle, the line of union being marked by a slight cingulum. In a few of the hindmost caudals the transverse processes were not anchylosed and have become detached, discovering a deep excavation in the end of the process-bearing tubercle.

Ribs.—Of these a very large number of fragments have been preserved. Most of these represent broad, horizontally compressed, flattened and channelled ribs, with a simple, vertically extended, roughened capitulum, corresponding in shape and size to the terminal surfaces of the transverse processes of the middle dorsal region. A smaller number of fragments indicate short subcylindrical ribs with a simple, smooth, rounded capitulum; they are doubtless the flanking ribs detached from the prethoracic and lumbar vertebræ. In addition to these two kinds of vertebral ribs, a great many smaller

cylindrical pieces deeply channelled on one side indicate the presence of the ventral set common in all *Plesiosauri*.

Breast and Shoulder-girdle.—The large flat bones, which can belong only here, differ so greatly from those of known *Plesiosauri*, that the only ones the determination of which can be looked on as at all certain are the coracoids (Pl. XLI. fig. 5). These are joined firmly together by a very stout median border, and form a strong flattened beam lengthened transversely to the axis of the trunk, attaining in this direction a maximum diameter of 20 inches at the lower end of the glenoid cavity, and one of 18 inches at the upper end of this articular surface. Each coracoid, then, is an oblong plate having a very short sutural median border which ties it to its fellow, and a gently concave anterior border decreasing in thickness from the outer end (where it contributes to the scapular articulation?) towards the middle, from which it again increases to its inner end, where the two coracoids meet in a remarkably strong non-articular projecting boss (*a*). Only a small piece of the natural posterior edge remains. It shows that this border curved inwards from behind the glenoid cavity towards the median line. How far the bone may have extended in this direction cannot be told; but, from the inclination of its ventral and dorsal surfaces towards each other, the mesial extension backwards would seem not to have been great. The outer border of the coracoid is stout; it bears a large, hollow, oval articular surface (the glenoid cavity, fig. 6, *a*), and in front of this a smaller trihedral surface, presumably for articulation with the scapular (*d*). The dorsal (?) surface of the coracoid is slightly sinuous. The ventral surface has a deep hollow just behind and parallel to the anterior border of the bone. A stout ridge sweeping from the median boss on the anterior border outwards to the glenoid border, divides this hollow from another triangular hollow, which lies between this ridge and the median crest. Below the outer end of this transverse ridge the ventral surface is convex from before backwards, and nearly plane transversely.

Limbs.—Of the four principal limb-bones the left pair are nearly perfect; my description is taken from these. One is rather shorter than the other; and this I assume to be the humerus, because in those Plesiosaurs in which there is any difference in the lengths of the humerus and femur the former is the shorter bone. In our Plesiosaur the humerus (fig. 1) is also stouter than the femur. Its length is $20\frac{1}{2}$ inches. Its proximal half is very massive and of a subcylindrical figure, while the distal half is expanded and flattened. The preaxial border (*c*) is nearly a straight line, broken both at the middle and towards the distal end by a slight excursion. The postaxial border (*d*) in its proximal 12 inches is nearly parallel to the preaxial one; but beyond this it sweeps backwards in a long curve and makes with the distal border a great wing, much larger relatively than that of typical *Plesiosauri*. The contour of the distal border (*b*) is formed by two slightly incurved lines which meet in a wide angle placed rather behind the axis of the bone. The postaxial division, which is much the longer, is, unfortunately, incomplete. This end of the

bone is unusually thick, reaching $2\frac{1}{2}$ inches at the angle; and the articular surface is correspondingly broad from the dorsal to the ventral margin. The proximal end bears a subhemispherical articular head (figs. 1 & 2, *a*), the axis of which makes an angle with that of the cylindrical shaft. A groove passing between the pre- and postaxial borders separates this articular caput from a prominent, non-articular, narrow, trochanteric upward production of the dorsal surface of the bone (fig. 2, *b*). The trochanter (mutilated in our specimen) descends a short distance along the postaxial border. The groove which separates this from the articular caput descends along both borders, on the postaxial one inclining to the ventral surface along the prolongation of the trochanter. A constriction below the articular head marks off on the ventral surface a smooth neck, beyond which the whole breadth of this surface and also the postaxial border of the cylindrical part of the humerus are occupied by a very rough and swollen muscular impression. The expanded distal part of this surface is smoother. From the preaxial border transversely, this surface is gently convex to the wing, where there is a shallow longitudinal hollow. The dorsal surface is smoother than the ventral. A low eminence appears at about one-third of the length of the bone, measured from the upper edge of the trochanter. I am unable to select the other bones of this fore paddle.

The femur (fig. 3) is rather longer than the humerus, and it is also less massive. This is particularly noticeable in the shaft. It has a subglobular articular head (figs. 3 & 4, *a*) placed obliquely on the shaft, separated, as in the humerus, by a groove from a very largely developed trochanter (fig. 3, *e*, & fig. 4, *b*), which projects strongly postaxially, and descends on this border of the shaft. The groove also descends on both borders of the bone. It is deeper than the corresponding groove in the humerus. The articular caput is followed by a smooth constricted neck, to which succeeds, on the ventral surface and postaxial border a large rough warty swelling. The preaxial border (fig. 3, *c*) is concave, not straight as is that of the humerus; and the postaxial border (*d*) is still more concave, its distal half curving strongly backwards, and making an extremely large wing with the distal border. This last border is very remarkable: its outline consists of three distinct segments, corresponding to as many divisions of the distal articular surface, which is one in excess of those present in typical *Plesiosauri*. The preaxial and the next postaxial division of this surface meet in a large angle lying just behind the axis, as in the humerus. Behind this is a second postaxial division of the articular surface, answering to the wing. The greater part of this, the third division of the distal articular end, is wanting; but its form is perfectly given by that of the corresponding bone in the second segment of the paddle.

This segment of the hind limb, the equivalent of the leg, contains in a transverse row three flattened angular bones of nearly equal size (*f*, *g*, *h*), each of which articulates proximally with one of the divisions of the distal articular surface of the femur, and distally with the members of the succeeding segment of the paddle. Laterally the

two outermost of the three bones articulate with the middle one. One of these bones lies preaxially; the other two are postaxial, the hindmost corresponding to the wing of the femur.

The preaxial bone (*f*) is pentahedral. It has a long proximal border, articulating closely (all the joints here are close-fitting) with the preaxial facet of the femur, and a rather shorter distal or tarsal border. Its mesial border, articulating with the middle bone, is shorter still. Its preaxial border, nearly straight, forms the front edge of this part of the paddle; it is smooth, transversely rounded, and non-articular. At its distal end a very short convex articular surface is intercalated between it and the long directly distal surface. The following are its dimensions in inches:—Preaxial border 3·7; proximal border 4·8; longer distal border 3·1 (its articular surface is concave from its dorsal to its ventral margins); shortest border, between the last and the preaxial one (having a smooth convex surface), 1·5. From the preaxial position of this bone, it is manifestly the tibia.

The first postaxial bone (*g*) is also a pentahedron; its long transverse diameter is 4·6 inches, and its short or axial diameter 3 inches. Proximally it joins the first postaxial division of the distal surface of the femur. Its distal border is formed by two articular surfaces (concave in both diameters), which meet, a little behind the short axis of the bone, in a salient angle. The line of union of the mesial border of this bone with the tibia nearly cuts the distal angle of the femur.

To the postaxial border of this bone the second postaxial bone (*h*) (the third and hindmost one in the row) articulates. Its proximal border articulates throughout its entire length with the femur*. Its postaxial border is convex and non-articular, forming here the posterior border of the paddle; and its short distal (tarsal) articular border makes with that of the middle bone a deep reentering angle. The transverse diameter of this bone is 5·7, and its axial diameter 3·4 inches.

The characters of the early cervical vertebræ and the long tapering neck prove beyond doubt this spinal column to be that of a *Plesiosaurus*, and differentiate it from the subgenus *Pliosaurus* as hitherto defined. From the length of the column (in its present incompleteness 15 feet) Mr. Mansel's *Plesiosaurus* must have attained a size as great as, perhaps greater than, *P. megadeirus* (Seeley), another Kimmeridge *Plesiosaurus*, represented by two series of associated bones from Haddenham and Ely, preserved in the Woodwardian Museum†. The absence of any published account of these fossils has prevented me from instituting so searching a comparison of them with Mr. Mansel's *Plesiosaurus* as I could have de-

* A line running from near the outer end of this border to the posterior border separates the proximal and posterior corner from the remainder of the bone. I am doubtful whether this is an accidental or a natural division; if the latter, the piece so separated is a fourth cnemial element.

† Catalogue of Ornithosauria, Aves, and Reptilia from the Secondary Strata, in the Woodwardian Museum, by H. G. Seeley, p. 97.

sired. From the figure of the conjoined axis and atlas of the Haddenham specimen, given by the late Mr. L. Barrett in 'Annals & Mag. of Nat. Hist.' 1858, and from some sketches of the coracoids, and of a restored paddle of the Ely one, there are evidently strong resemblances; but Mr. Davies, sen., of the Palæontological Department of the British Museum, whose opinion in a matter of this kind is justly entitled to great weight, tells me that he has seen the Haddenham spinal column, and believes it to represent a distinct species from Mr. Mansel's.

A comparison of the limbs of Mr. Mansel's, and also of *P. megadeirus*, with those of the typical Liassic *Plesiosauri*, brings out so many and such important differences that these two Kimmeridge Enaliosaurians may well rank as the representatives of a very distinct subgenus.

Their coracoids are not produced forward mesially far in advance of the level of the glenoid cavity as they are in the Liassic *Plesiosauri*, but their anterior borders make a nearly straight line. They are also much extended transversely to the trunk's axis, while their greatest extension in the Liassic *Plesiosauri* is in the direction of the axis.. In this the coracoids of the Kimmeridge *Plesiosauri* show a resemblance to *Ichthyosaurus*; but their front border wants the characteristic Ichthyosaurian notch.

The humerus and femur of Mr. Mansel's *Plesiosaurus* are absolutely, as they are also relatively to the length of the spinal column, longer than in any known Liassic *Plesiosaurus*. They are also more massive, and their muscular impressions are much stronger. Their subglobular articular caput appears to me to make a larger angle with the axis of the bone; and there is also the well-developed trochanter. The postaxial border has a larger backward curve; and the wing is much larger. The distal end of the femur (that of the humerus is incomplete; but by analogy it should resemble that of the femur) has a third articular facet, while that of the humerus and femur of Liassic *Plesiosauri* has two articular facets only. The second segment of the limb, the cnemion, contains three coequal bones, articulating with the three femoral facets, and answering to the tibia, fibula, and an additional element. The Liassic Plesiosaurian femur has only two distal facets, and but two principal bones in the second segment of the paddle. In some species, however (*P. rugosus*), a rudimentary third ossicle is present at the postaxial border of the fibula. The two principal bones, the tibia and fibula, in these latter Plesiosaurs are elongated in the direction of the axis of the limb, and they are very different in form from the tarsal bones; whereas in the Kimmeridge *Plesiosaurus* the three coequal bones in the cnemion are lengthened transversely to the axis of the limb, and differ little in shape from the tarsals. In this formal indifferentism of its cnemion and tarsus, Mr. Mansel's *Plesiosaurus* has a resemblance to *Ichthyosaurus*; but the similarity is more than balanced by the third bone in its cnemion and the perfect formal difference of the digits.

It is, however, in the subgenus *Pliosaurus* that the limbs most

closely resemble those of this Kimmeridge *Plesiosaurus*; and the points of similarity are just those wherein this departs from the Liassic types.

I find, on comparing them, a very close general and particular agreement between the humerus and femur of the Kimmeridge *Plesiosaurus* and two type specimens in the British Museum, labelled "No. 31,795. Femur, Plesiosaurus trochanterius, Owen," and "No. 31,787, femur of Plesiosaurus brachydeirus, Owen." No. 31,795 is smaller than the Kimmeridge humerus, but in all other respects closely resembles it. It has the same general form, articular caput, trochanter and separating groove, and the rough warty muscular impression on the ventral surface and postaxial border. The preaxial and first postaxial segments of the distal border are inclined at a similar angle; the preaxial segment is similarly concave. The remainder of this and the distal part of the postaxial border, including the wing, are unfortunately wanting, so that the comparison cannot be completed.

The Kimmeridge Plesiosaur's femur is extremely like No. 31,787, a femur of "Plesiosaurus brachydeirus, O.," a longer bone (from a larger individual?), but with outlines which, so far as they are preserved, closely resemble those of the Kimmeridge *Plesiosaurus*. At first sight most striking differences are a greater axial symmetry due to the smaller size of the wing, and the subdivision of the distal end into two facets only; but it only requires a second glance to see that the distal third of the postaxial border, with the corresponding part of the wing and of the distal border, have been broken off, and the rough fractured edge smoothed with plaster of Paris. It has a similar articular caput, separated by a groove running between the preaxial and postaxial borders from a strongly formed trochanter. The preaxial and so much as remains of the postaxial division of the distal end are inclined at a like angle, and each is similarly concave.

When the comparison is extended to the second and third segments of the limb, similar resemblances are apparent. The paddles available for this purpose are two—the well-known enormous paddle of *Pliosaurus grandis*, presented to the Dorchester Museum by its discoverer and restorer, Mr. J. C. Mansel, and the small paddle of *Pliosaurus portlandicus* in the British Museum, described and figured by Professor Owen in the Palæontographical Society's Memoirs, vol. xxii.*

In both these we notice the same formal indifferentism of the bones composing the cnemion and tarsus, and the same transverse extension of the tibia and fibula. In the Dorchester paddle, an excellent cast of which is in the north gallery of the British Museum, the femur is mutilated. It manifestly wants a great part of the wing, which has been split off by a straight fracture parallel to the axis running from the postaxial to the distal border. The tibia and fibula support flat multiangular tarsals, which are succeeded by five

* Fossil Reptilia of the Kimmeridge Clay, genus *Plesiosaurus*, by Prof. Owen (Paleontogr. Soc. Mem. vol. xxii. for 1868), pl. 4. fig. 1.

digits. As often as I looked at the cast of this gigantic paddle ($6\frac{1}{2}$ feet long), I was struck with the insufficient basal support of the hindmost digit, and the suspicion forced itself upon me that something was wanting in the postaxial side of the foot. The Portland paddle proved this to be the case. Its second segment contains two coequal bones, and part of the distinct impression of a third, which has fallen out of the matrix; and corresponding to this impression in the stone there is, as may be plainly seen in the excellent figure illustrating Prof. Owen's memoir, the beginning of a second postaxial facet on the distal end of the femur. The rest of this facet, with the adjacent postaxial border, has been worn away. Prof. Owen regards the third ossicle in the cnemial row as "the homologue of the fabella which is present in some *Plesiosauri* (*P. rugosus*, for example), where its homotype in the fore limb is represented by a detached olecranal process of the ulna," adding "that the bone in *Pliosaurus portlandicus* is relatively larger and less triangular in shape than in *Plesiosaurus rugosus*." Afterwards, describing the hindmost of the three bones present in the first row of the tarsus, which he regards as the calcaneum, Prof. Owen writes of its posterior border, "It appears to have been closely connected with the fabella (67′), which fits into the interspace between the fibula and the calcaneum; and whether to regard the ossicle marked 67′ as the apophysial lever of the fibula or as the calcaneum may be a question"*.

The identity of the third cnemial bone of our Kimmeridge Plesiosaur with that which has left its impression in the matrix in which lies the Portland *Pliosaurus*-paddle cannot, I think, be questioned; and the correspondence of this to the ossicle attached to the posterior border of the fibula of *Plesiosaurus rugosus*, pointed out by Prof. Owen, appears highly probable. If this be a true correspondence, and not simply an apparent one, the determination of the serial homology of the bone is still open; for no confirmation of either of the two hypotheses is to be drawn from the Kimmeridge paddle. If the ossicle attached to the fibula in *Plesiosaurus rugosus* is the homologue of the "apophysial lever of the fibula" (the styloid process of human anatomists), we have the anomaly of its lateral, not terminal, articulation with the shaft of the fibula, and also of its articulation with both the femur and the tarsus. If, however, it is the calcaneum, we have another anomaly—the articulation of the heel-bone and femur—besides the difficulty of reconciling this determination with that of the hindmost of the three bones of the first tarsal row, which the author of the memoir quoted regards also as the calcaneum.

We have not yet, I think, sufficiently complete material for the solution of this problem, and we must be content to wait for fresh material before the homology of the bone can be settled. At present, I will merely say that its existence as a coequal bone with the fibula and tibia in the Kimmeridge *Plesiosaurus* is in harmony with the ingenious theory of the type of limb-construction recently advanced

* Paleont. Soc. vol. xxii. 'Fossil Reptilia of the Portland Stone,' p. 11.

by Gegenbaur,—and conclude with the remark that this additional cnemial element, extending, as it does, the basis of support of the tarsus and digits, suggests the presence of additional postaxial digits above five, the number in the Liassic *Plesiosauri*. Should this prove so, it will add another and a striking resemblance to those already known between this subgenus of *Plesiosaurus* and the *Pliosauri* and *Ichthyosauri*. I propose to distinguish this new Kimmeridge *Plesiosaurus* by the specific name of *Manselii* (*Plesiosaurus Manselii*).

Dimensions of Centra of Vertebræ.

	Antero-posterior diameter.	Transverse horizontal diameter.	Vertical diameter.	Distance between upper border of transverse process and level of upper surface of centrum.
Cervical.	inches.	inches.	inches.	inch.
No. 1	·8	1·2	1·2	·8
2	·8	1·3	1·0	·7
6	1·8	1·7	1·7	1·3
12	2·2	2·1	2·5	1·8
27	2·5	4·0	3·2	1·9
Transitional ...	2·4	4·4	3·4	
Dorsal	2·2	4·2	3·6	
Caudal.				
No. 1	2·2	4·3	3·4	
6	1·9	3·6	3·0	
12	1·6	2·7	2·2	
16	1·0	1·4	1·5	

EXPLANATION OF PLATE XLI.

Figs. 1 to 6 illustrate the osteology of *Plesiosaurus Manselii*.

Fig. 1. Ventral view of left humerus: *a*, proximal end; *b*, distal end; *c*, preaxial border; *d*, postaxial border.

Fig. 2. Proximal end of this humerus: *a*, articular caput; *b*, trochanter.

Fig. 3. Ventral view of left femur: *a*, proximal end; *b*, distal end; *c*, preaxial border; *d*, postaxial border; *e*, trochanter; *f*, preaxial bone of leg; *g*, first postaxial bone; *h*, second postaxial bone.

Fig. 4. View of proximal end of this femur: *a*, articular head; *b*, trochanter.

Fig. 5. Dorsal view of conjoined coracoids: *a*, front border; *b*, posterior border; *c*, *c*, glenoid fossæ; *d*, scapular facet.

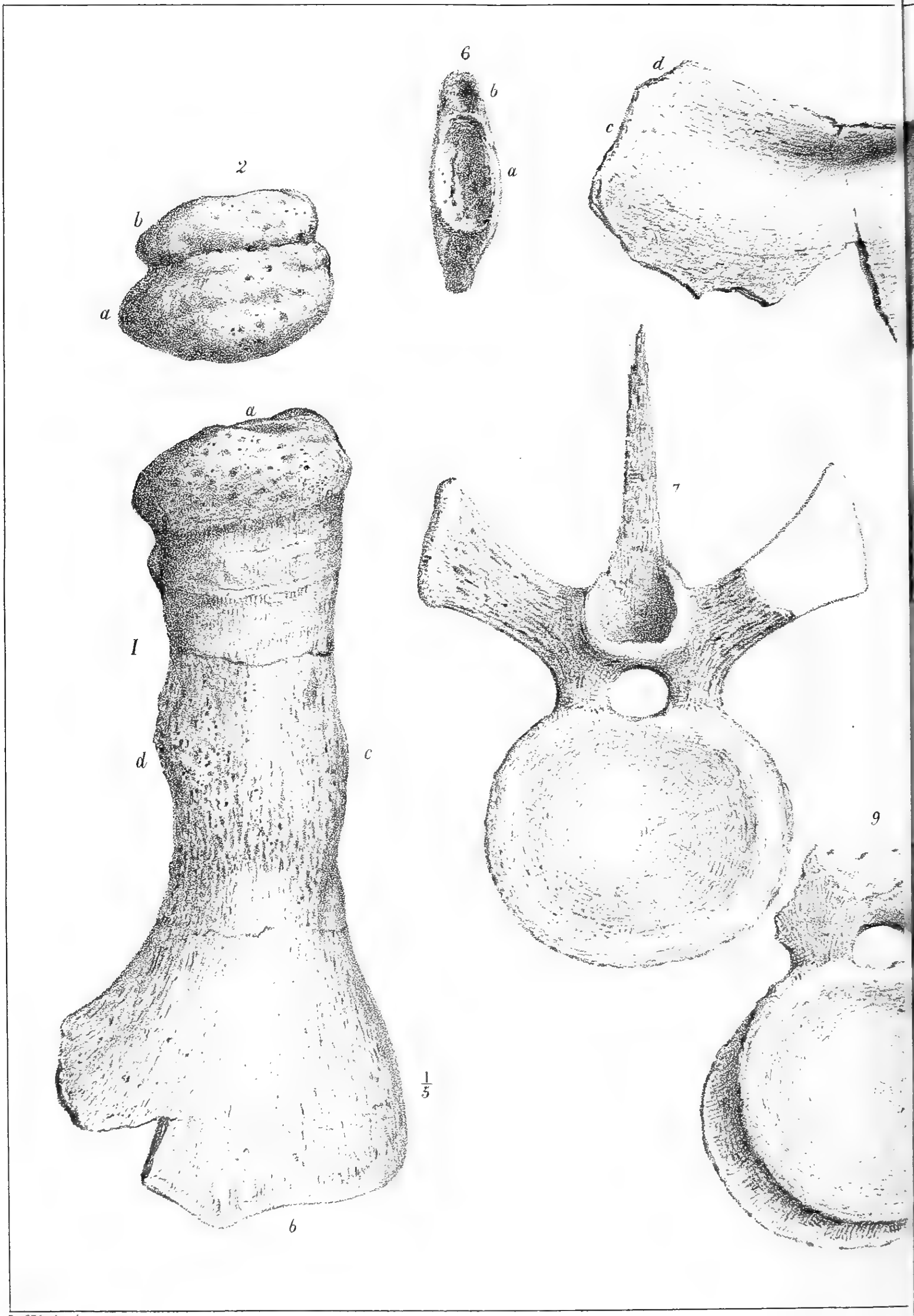
Fig. 6. View of outer end of coracoid: *a*, glenoid cavity; *b*, scapular facet.

Figs. 7, 8, 9. Vertebræ of *Plesiosaurus brachistospondylus*.

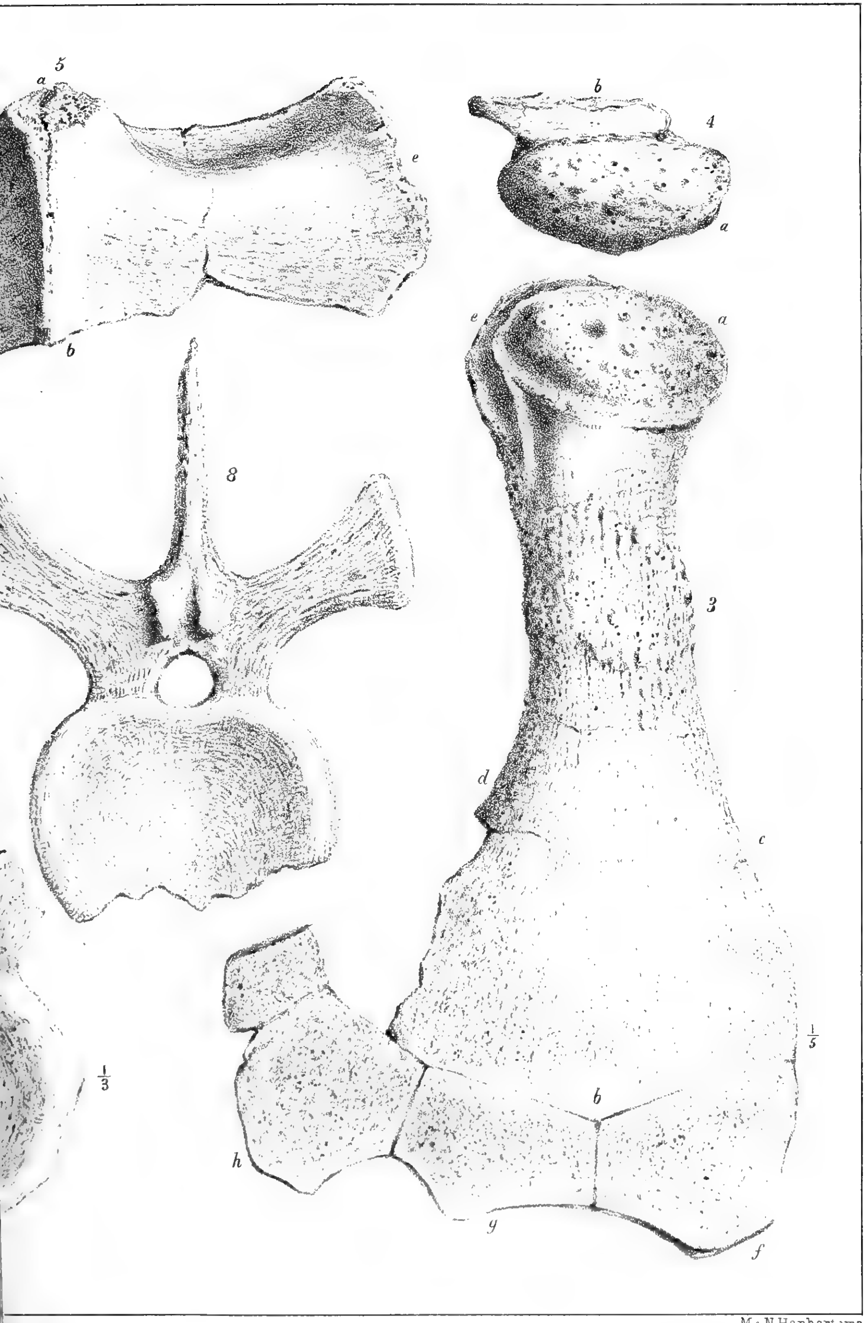
Fig. 7. Front view.

Fig. 8. Back view.

Fig. 9. Oblique view, showing the antero-posterior diameter or length of the centrum.

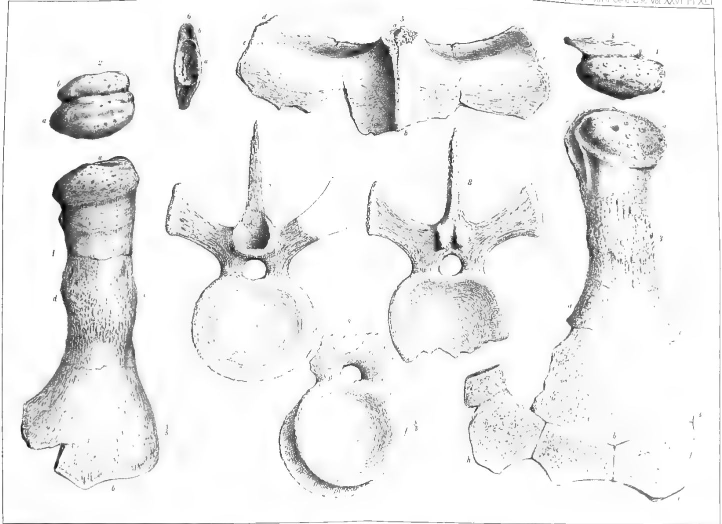


KIMMERIDGE



M & N Hanhart imp

SIOSAURI



KIMMERIDGE PLESIOSAURI

4. *Notes on the* GEOLOGY *of the* LOFOTEN ISLANDS. By the Rev. T. G. BONNEY, M.A., F.G.S., Tutor of St. John's College, Cambridge.

[Abstract.]

THE author described the general appearance of the Lofoten Islands, which have commonly been described as composed of granite, but which, he stated, really consist of gneissic rocks. The scenery of some of the islands on which he did not land resembled that of the Cambrian and Cambro-Silurian districts of Wales and Cumberland; and the interior of Hassel showed dark rounded fells, resembling in outline some of the softer Welsh slates. At Stokmarknæs and at Melbo there is a granitoid rock of pinkish-grey colour, consisting of felspar and platy hornblende, with some mica and quartz. The Svolvaer Fjeld in Ost Vaagö shows a distinctly bedded structure in the cliffs near Svolvaer, the débris at the foot of which consists of a rock resembling syenite, and a quartzite containing a little hornblende and felspar. Bedding was also observed towards the Oxnæs Fjord. The islets near this coast consisted chiefly of a granitoid rock resembling a syenite, showing traces of bedding to the west of Svolvaer. Veins of quartz and seams of hornblende &c. occurred in some of the islets; and the latter were too regular to be explained by deposition in fissures. Near the Svolvaer post-office there was gneiss coarsely foliated, containing hornblende and mica, with pink orthoclase felspar. The author concluded, from his observations, that, with few exceptions, the so-called granites of the Lofoten Islands are stratified, highly metamorphosed rocks—quartzites and gneiss, generally with much felspar in the latter, and with more or less hornblende in both—and that they are inferior in position to the gneiss and schists of the mainland, and to the more slaty rocks of the southern and western parts of the same islands. He compares them with some gneiss from Dalbeg on the west coast of the island of Lewis, and thinks it highly probable that they also are of Hebridean age. The remainder of the paper described some raised beaches and moraines. The latter are frequent in the Raftsund at the mouth of tributary glens, and just above the sea-level.

---

5. *On* DORYPTERUS HOFFMANNI, Germar, *from the Marl-slate of Midderidge, Durham.* By ALBANY HANCOCK, Esq., F.L.S., and RICHARD HOWSE, Esq.

(Communicated by Prof. T. H. Huxley.)

[PLATES XLII. & XLIII.]

WITHIN the last few years four specimens of *Dorypterus Hoffmanni* have been discovered in the Marl-slate of Midderidge, in the county of Durham, by Joseph Duff, Esq., two of them in the year 1865, and the other two in the autumn of last year, 1869. A few traces of other individuals were also observed at the same time and in the same locality. These are, we believe, the first specimens of this

very singular fish that have been obtained from the Marl-slate of this country.

The Midderidge quarry, in which these examples were found, is situated on the Darlington and Wear Valley Railway, not far from Bishop's Auckland, and is well known as being the locality where the Marl-slate fishes were first discovered. Prof. Sedgwick a long time ago (Trans. Geol. Soc. 2nd series, vol. iii. pp. 76, 77) accurately described the position of this quarry and the stratum in which these specimens were found.

Through the kindness of Mr. Duff, we have had the opportunity and pleasure of examining and studying all the specimens of this interesting fish: and this has happened fortunately; for each specimen, being in a different state of preservation, has assisted much towards the working out and comprehension of the structure of this extraordinary ichthyolite.

When Mr. Duff's original specimens were first seen, they were supposed to be merely the skeletons of a species of *Platysomus*; but a short examination soon showed that this opinion was entirely erroneous; and happily the discovery of two more specimens, and especially of one in which the characteristic dorsal fin was better preserved than in the former specimens, led us at once to identify Mr. Duff's discovery with the *Dorypterus Hoffmanni* described originally by Prof. Germar in Count Münster's Beiträge zur Petrefactenkunde (Heft v. pp. 35–37, tab. xiv. f. 4), from a specimen obtained from the Kupferschiefer of the Eisleben district.

Also there appears to us not the least doubt that the two fishes described by Count Münster in the same work (Heft v. p. 44, tab. v. f. 2), under the name of *Platysomus Althausii*, belong also to the genus *Dorypterus*, and to the same species as the one described by Prof. Germar. But in order to establish more satisfactorily the strict identity of these with the English specimens, it seems necessary to reproduce the original descriptions given by Prof. Germar and Count Münster.

Dorypterus Hoffmanni, Germar (Heft v. pp. 35–37). "This specimen was found only last autumn (1840) in the Kupferschiefer of the Eisleben district; and, although it is not perfect enough to ascertain all its essential parts, yet it presents so many peculiar characters that the establishment of a distinct genus becomes necessary. As generic characters one can point out:—an oval profile and a body flattened on the sides, with a distinct bony skeleton; a very high and spit-shaped dorsal fin; pectoral fin placed in the mid-height of the body, behind the gill-cover; the small, narrow ventral fins in the middle of the ventral margin; and a fork-shaped, equal-lobed tail.

"The whole length of the fish, from the tail-fin to the front of the jaws, is 3 inches 7 lines; its height, without the fins, 1 inch 11 lines; the height of the dorsal 2 inches, its breadth in the middle 1 line. The head, broadly ovate, has a nearly semicircular outline; the under jaws are much bent upwards; and also the front and the nose seem much bent downwards. It occupies nearly one-third of the

body; and the jaws do not appear to have borne teeth. The backbone has a few more than thirty-joints, of which about seventeen belonged to the ventral vertebræ; but the number of the vertebræ cannot be distinctly reckoned.

"Satisfactory information cannot be given respecting the pectoral fins. Behind the gill-covers a somewhat waved ribbon-shaped organ runs in a sloping direction backwards to the ventral margin, which perhaps might be the humerus; and at its root one sees some bones which one is inclined to take for the roots of the pectoral rays. But this ribbon-shaped organ is provided with distinct parallel longitudinal striæ, and itself resembles a pectoral fin; and those bones we took for roots of the pectoral rays might be apophyses of the vertebral column displaced by pressure.

"The little elliptical ventral fins are nearly behind the middle of the belly, and not in immediate connexion with other bones, and may perhaps, through pressure or dislocation, have been pushed backwards; but at any rate they are placed behind the pectorals. The anal fin itself is not to be seen; but the root-bones (fin-supports), which are present, show that it commenced close to or not far from the ventrals, and extended for a considerable distance towards the tail.

"The dorsal commences a little before the middle of the back, quickly gets narrower towards the apex, and continues in a vertical direction, with pretty equal breadth, to the tip. It has in this example, on the hinder side at the base, a bow-shaped emargination, which, however, may not have been caused by tearing or injury, because the rays do not break off, but run in parallel curves to the root. The support-bones also show that the dorsal did not extend more behind than before, and that we have the dorsal fin perfect and complete before us. The existence of a second dorsal cannot be directly denied, because in the place where it should appear the fish becomes obscured by the stone, and there are no sharp lines; but occasionally one can see the outline of the back so clearly that one would certainly see bones if there had been a second dorsal; and we may therefore conclude that, in all probability, it was absent.

"The caudal is forked; both lobes are equal, and are separated by the backbone.

"It is all the more difficult to determine the family to which this fish belongs, as neither scales nor teeth are to be seen. The rhombical markings which the figure shows near the tail, and which one might take for scales, have no glistening surface, and appear more as fragments of ribs and spinous processes crossing each other. If they were really scales, the genus *Dorypterus* would then belong to the Ganoids, and stand near *Dapedius*. But the form, the situation of the fins, and the whole skeleton remind one very much of the recent genus *Vomer*."

Although Prof. Germar's specimen was not perfect enough to enable him to describe it fully, yet in the foregoing description we find a sufficient number of characters to justify us in referring our specimens to this peculiar fish. Among these the position of the

lower jaw, the rather large orbit, and the unusually long dorsal fin would alone be sufficient to establish this identity; but to these points may be added the situation of the pectoral in the mid-height of the body, the curious "ribbon-shaped" process descending from behind the pectoral to the ventral margin, the abdominal rod which bounds the ventral cavity behind (not mentioned by Germar or Münster, but characteristically shown in their figures) the hour-glass-shaped processes beneath the dorsal, and the peculiar sigmoidal plates seen near the ventral margins of the posterior half of the body: these establish beyond any doubt, not only the generic, but also the specific identity of the Marl-slate with the Kupferschiefer specimens. But there are a few points in Prof. Germar's description which the more perfect state of the specimens we have had the use of enable us to correct. It will appear in the sequel that what seemed to Germar to be an internal bony skeleton is, according to our observations and opinions, also in part an exo-skeleton. The situation of the ventral fin also, which is placed in this fish under the throat and rather in advance of the pectoral fin and ventral cavity, has been overlooked by this author (for, judging from his figure, the ventral appears to be present); and in consequence of this oversight, he has been led to consider the anal the ventral, and the anal (which is well shown in his specimen) not to be present. Another point deserving of remark is the statement that the tail is homocercal. This idea arose, no doubt, from the imperfect state of the tail in the specimen examined; but in those which we have investigated this fin is very well preserved in three individuals, and shows itself to be decidedly heterocercal. The size of Germar's specimen is rather less than that of three of ours; but the dorsal fin is more perfect and more characteristically shown in the German than in those which we have before us from Midderidge.

Count Münster says of his *Platysomus Althausii* (Münster, Beiträge, Heft v. p. 44, tab. v. f. 2) that "the only two small individuals of this species which I saw at Mr. Althaus's are of equal size, but both without scales, so that only the skeleton of the fish is seen, an appearance very common in the lithographic slates of Bavaria, but very rare in the Kupferschiefer. One recognizes pretty clearly the very strange composition of the skeleton of this fish, which Agassiz has fully described in 'Recherches sur les Poissons Fossiles.' Only faint impressions exist of each individual.

"The individual figured (Taf. v. f. 2), which Mr. Althaus was so kind as to let me have, has at the first superficial glance some resemblance in its external form to *Platysomus gibbosus*, Agassiz, so that at first I thought this might be only the skeleton of a young individual of that species; but a stricter investigation and comparison soon convinced me that it is an entirely new species.

"The body has a rounded rhomboidal, nearly ovate form. The head is disproportionately large, and occupies nearly one half of the body; its profile from the dorsal fin to the snout is somewhat straight; the snout much bent. The large orbit is placed high and far backwards. The faint impressions of the head-bones are

smooth, without striæ or granulations; but their appearance is not very distinct. The hind border of the operculum or gill-plate is narrow; near to it is placed the left pectoral fin, which has probably been pushed so high up by pressure from without. One recognizes only the impressions of a few rays: below, on the margin near the anal, the rays of a small fin are shown, which appear to have belonged to the ventral; for although, until now, on the specimens of the genus *Platysomus* which have been examined by Agassiz, Germar, and others ventral fins have not been seen, yet I have found them on two examples of *P. Fuldai* (=*Platysomus macrurus*, Ag.).

"The dorsal fin is somewhat large; the commencement of it is near the head, in the central part of the back. The anal stands opposite to it, and is nearly of the same form and size, but is situated nearer to the mouth than to the tail; for it reaches nearly to the head. The rays of both fins run to the tail, and are very fine. On the example before us, fragments only of the rays of the continuation of the dorsal could be seen.

"The pedicle of the tail is remarkably narrow, only about a line broad; the deep-forked fin is proportionally very large. Of both lobes the extremity is wanting; but it seems that the upper lobe was not much longer than the lower, which is a little broader.

"There is, as mentioned before, no trace of the scales."

In Münster's figure of *P. Althausii*, the posterior part of the body, allowing for the slightly different state of preservation, much resembles ours. The form of the abdominal cavity, bounded in front by the "ribbon-shaped process," and posteriorly by the abdominal rod, is identical. The position of the pectoral fin is also the same, though thought by Münster to have been disturbed and pushed upwards out of its true position. The prolongation of the dorsal fin is destroyed, as in most of our specimens; and the bones of the head are much displaced, and moved downwards and backwards towards the ventral cavity; but these bones are said to be smooth and without striæ or granulations—a character which at once distinguishes this fish from *Platysomus*, in which the bones of the head are always more or less ornamented with granulations or striæ.

In Münster's example the anal fin is finely preserved, and shows very distinctly its continuation to the tail; but by displacement and pressure of the bones of the head downwards, the ventral fins, which Münster saw, but could not describe rightly on account of the disturbed state of his specimen, have been pushed backwards, and brought nearly into contact with the anal fin; and thus one of the striking peculiarities of *Dorypterus* (the thoracic or jugular position of the ventrals) remained till now unobserved. It will, we think, be admitted by every one who carefully collates Münster's figure and description of *P. Althausii* with those of Germar's *Dorypterus Hoffmanni*, that they are perfectly identical; and we adopt the latter name for the species, as it has a slight precedence in order of description, and was, besides, more strongly characterized than the former.

The German specimens of *Dorypterus* were obtained from the

Kupferschiefer of Richelsdorf and the Eisleben district, where it appears to be very rare.

Dorypterus is pretty regularly oval in contour, inclining to ovate, the posterior slopes being more rapid than the anterior, and the head rather obtuse. It was probably much compressed, and is very deep in proportion to its length; the length of the body, including the central rays of the tail, is about twice its depth at the deepest part. Our largest specimen is 5 inches long, including the tail, and $2\frac{1}{4}$ inches deep; and the head, from the anterior extremity of the mandible to the posterior angle of the gill-plate, is about one-third the length of the entire animal, including the centre rays of the tail. The muzzle is obtuse, the mouth shutting upwards; the mandibles are long, flat, and rather wide; the præmaxillæ are about half the length of the mandibles, and, like them, are flattened and wide; the maxillæ are about as long as the præmaxillæ, and bend downwards, and overlap the posterior portions of the mandibles. The gape was large; and the jaws probably shot out a little when in action; no teeth have been observed.

The orbits (Pl. XLII. fig. 1, *u*) are large, and are situated immediately behind the præmaxillæ and a little below the brow or dorsal ridge; the gill-plate or operculum (*s*) seems to be composed of two pieces, and is of a narrow crescent-form, the posterior margin being a little angulated, the angle projecting above the middle longitudinal line of the body. The præoperculum (*t*) partakes of the same form, but is considerably less than the operculum, and is placed about midway between the eye and the posterior margin of the gill-plate.

The clavicle (*r*), which is well preserved in one of the specimens, is a long, stout, fusiform bone, extending from above the longitudinal middle line of the body to the insertion of the ventral fin, and is well inclined thence upwards and backwards.

The pectoral fins (*c*), which are $\frac{8}{10}$ inch long, are wide and somewhat rounded, the extremity being obtuse; they are rather large in proportion to the size of the body, and are situated just behind and below the angle of the operculum, consequently on the central longitudinal line. They are connected with the upper portion of the clavicle. The remains of apparently the scapula and coracoid were observed in one of the specimens; they are, however, in a crushed state, but seem to have been broad, flat, and short, and are arched towards each other. From these extend fourteen or fifteen flat and rather delicate brachial rays (*c'*), the longest of which are near the middle and measure rather more than $\frac{1}{8}$ inch in length; they are articulated with double their number of simple fin-rays, which are composed of numerous joints.

The ventral fins (*d*) originate in front of the ventral or thoracic plates, to be shortly described, and immediately behind the lower extremity of the clavicle, and incline backwards; they are upwards of half an inch in length, are proportionally narrow and are sharp-pointed; they have each about fourteen or fifteen rays, which are made up of numerous joints, and are attached to elongated narrow pelvic bones; but these are too much obscured to admit of complete description.

The posterior extremity, however, is a little enlarged, and appears to have been the articular surface.

The enlarged part of the anal fin (*b*) is placed near to the transverse centre of the body. It is about half an inch long, and is triangular, with the extremity pointed, the posterior margin being slightly convex, the anterior straight or a little concave. The base extends nearly as far forwards as the posterior ventral plates, being prolonged in this direction by seven or eight pointed scale-like rays or plates, which diminish in length forwards; and it is continued backwards to the root of the tail as a low fringe (*b'*), about $\frac{3}{16}$ inch wide, supported by rather distant delicate rays, but whether jointed or not could not be determined. The anterior elongated portion is composed of between twenty and thirty simple, jointed rays, the joints being rather long, with the articular extremities slightly enlarged.

The dorsal fin (*a*) has a very extraordinary development; its anterior elongated portion is estimated to be as long as the whole fish *minus* the tail, and rises up from the dorsal ridge a little in advance of the centre, consequently just in front of the position of the anal fin, in the form of a scimitar slightly bent forwards. It seems to have been in the larger specimens upwards of $4\frac{1}{4}$ inches in length, and is extremely narrow, being only $\frac{2}{10}$ inch wide an inch from the base, gradually tapers to a fine point above, and as gradually widens downwards to within $\frac{3}{8}$ inch of the base, which suddenly expands, stretching forwards almost as far as the occiput, and backwards to the root of the tail, as a narrow fringe, similar in height and appearance to that on the opposite or ventral margin. The anterior prolongation (*a''*) is composed of a double lateral series of about twelve low, stout, pointed, scale-like rays or processes, the fin-fulcra, inclining and increasing in length backwards. The first of the series is extremely short, just appearing above the dorsal ridge; the last is about $\frac{4}{10}$ inch in length; and the whole, leaning in the direction of the fin, one supporting the other, form, as it were, a sort of buttress to the base of the enormously elongated fin. Only a few of the central rays reach to the top of this elongated portion of the fin; both in front and behind they die out gradually. At the base, just above the anterior fin-fulcra, there are twelve or thirteen rays; halfway up they are reduced in number to seven or eight; and within half an inch of the top, judging by the upper portion of a fin in our possession, there are only four or five. All the rays are divided into numerous and unusually elongated joints (fig. 4), which at the points of articulation are slightly enlarged. The joints are longest in the centre or anterior rays, some of them measuring $\frac{1}{10}$ inch in length.

The tail is distinctly heterocercal, and is deeply and regularly forked, the upper lobe being only a little longer than the under. The former is $1\frac{1}{4}$ inch in length; and from tip to tip of the lobes the tail is $1\frac{1}{2}$ inch in width. The anterior margin of the upper lobe is defended by a closely arranged series of stout, sharply pointed, enamelled, scale-like processes or fin-fulcra (fig. 1, *f*), which imbricate and diminish in size backwards. Behind or below these there is a double row of rhombiform scales (*e*), likewise covered with enamel

and articulating lengthwise by notches and points. The fin-rays, which occupy more than half the width of the entire lobe, are rather delicate, jointed, and bifurcated once or twice at the extremities. The rays are longest and are much inclined on the lobes, and become shorter and less inclined in the axis of the fork.

Perhaps the most curious feature in this interesting fish is found in the character and mode of arrangement of the more or less bony plates and rods, regarded by Germar as composing an internal "bony skeleton;" and, indeed, in the general disposition of the component parts there is a strong resemblance to such. On examining them in detail, however, there are one or two anomalous features which render it difficult to work out the homologies of the bones; and the discrepancies are of a nature to raise the questions, Do, indeed, all these bones really belong to an endo-skeleton? and may they not in part belong to an exo-skeleton? Before, however, entering on these points it will be better to describe the form and arrangement of these peculiar plates and rods. And for the sake of avoiding circumlocution, and to simplify the description, we shall give to the various parts distinct names, referring only occasionally to those in general use, for the purpose of pointing out resemblances.

The plates and rods are arranged in transverse series, of which there are twenty-seven or twenty-eight, extending from the occiput to the root of the tail, reminding one much of the disposition of the transverse flakes of muscle observed on the sides of the body of a fish when the skin has been removed. These transverse series of plates and rods are, for the most part, placed a little asunder, but are at some points in contact, and occasionally seem as if imbricated. They are in contact along the longitudinal middle line, which corresponds to the usual lateral line or the line of the vertebral column. Here there is a chain of lozenge-shaped plates or areas (*h*) with their angles placed lengthwise and transversely. In the centre of each there is an elongated rounded ridge (fig. 2, *h'*) placed longitudinally; these ridges resemble the mucus-tubes of the lateral line of certain fishes.

These lozenge-shaped areas or plates measure about $\frac{1}{10}$ inch across. From either side of each of them there extends a longitudinal transversely elongated plate (figs. 1, 2, *g*) inclined backwards, the largest of which measures about $\frac{1}{4}$ inch in length; these, which we shall call the lateral plates, are expanded and bifurcated (*g'*) in the direction of the length of the fish at their inner extremities, and thus embrace, as it were, the lozenge-formed areas or plates bearing the ridges already described; or perhaps this arrangement would be better described by stating that the forks of the opposed plates, meeting on the median line, form the lozenge-shaped areas or plates, to which they give an elevated border. The lateral plates have a boss-like enlargement at the point of bifurcation; here the plates are narrowest; hence they widen gradually for some distance, and then, turning backwards, taper to the termination. The margins are abruptly defined, and are slightly elevated into narrow ridges, which die out towards the outer margin. The bifurcations of the adjacent plates are in contact; and so are the outer terminations. But for the rest,

the plates are divided by a lanceolate space. The tapering distal or outer extremities of the lateral plates are united each to a stoutish rod (*i*), which at the point of union is cylindrical and somewhat enlarged. These are slightly arched backwards and inclined considerably in the same direction; their outer extremities are a little widened, flattened, and grooved longitudinally; and, suddenly contracting, they turn forwards, and each becomes joined to the inner pointed extremity of a sigmoidal ridge-like plate (*j*), which rises boldly up, and which, inclining much forward, terminates in a recurved sharp point a little within the general margin of the fish. The sigmoidal ridges gradually widen in the centre, where there is a longitudinal groove; and they, as well as the rods, are divided from each other by a considerable space. Such is the general appearance of these sigmoidal ridges or plates; but on closer examination the ridges are found to be formed of the turned-up edges of wide flat sigmoidal plates (*j'*), which extend from ridge to ridge.

Such is the description of the transverse series of plates and rods of the posterior half of the body, numbering sixteen or seventeen corresponding to the caudal vertebræ, to which the lozenge-shaped areas and lateral plates have a strong resemblance. On the anterior half the dorsal members of the transverse plates and rods are somewhat modified. The central lozenge-shaped plates bearing the ridges and the elongated lateral plates are continued to the occiput unaltered in character, or only slightly changed in form. Below, or towards the ventral margin, the sigmoidal ridges or plates seem to be replaced by a series of seven large thoracic or ventral plates (*m*), which are arranged along the margin of the body, those of the two sides meeting on the median line, where doubtless they formed a sharp edge. They are $\frac{3}{8}$ inch long, and about $\frac{1}{8}$ inch wide.

They *appear* to imbricate forwards, and are of an irregular ovate form, with the posterior margin thin and somewhat flattened, and the anterior or overlapping margin thickened, grooved, and a little shouldered above. We say *appear* to imbricate forwards; but in the most perfect specimens there are indications that they are really imbricated backwards, the groove of the anterior margin receiving the thin posterior border of the preceding plate; and the appearance to the contrary seems to be owing to dislocation. Both extremities of the plates are drawn out, the lower one being considerably prolonged, pointed, and directed backwards. The upper extremities are directed upwards and forwards, and are produced into widish columns (*n*) (the ribbon-shaped organ of Germar), the two or three anterior of which, increasing in length backwards, terminate immediately behind the clavicle. The posterior ones pass upwards, and are united to the outer extremities of the lower lateral plates near the occiput. These columns, which are divided by narrow spaces, present a very peculiar appearance. Each of them is composed of numerous, narrow, much elongated plates or rods, with pointed extremities, which, overlapping each other considerably, give to the whole a sort of twisted look. They are probably, however, in a disturbed state. About seven of the lower lateral plates next the occiput are

in connexion with these columns, which seem to divide into their component parts as they approach them, two or three being thus joined to each column; but in all our specimens this part of the fish is injured. The lateral plates are narrower than those lower down the body, and apparently gradually subside into the columns, without any distinguishing point.

These lateral plates at this point incline forwards; the few next lower down are much inclined backwards; so that there is here a large space over the abdominal region devoid of all such appendages. In all the four specimens this is the case, as well as in the German specimens before referred to; and it is therefore probably the natural condition, and is not owing to accidental circumstances, though it is possible enough that pressure may have had something to do in forcing the plates asunder.

The ventral plates (*m*) extend from the root of the ventral fins to almost the commencement of the anal; and from the lower part of the posterior plate there is a stout rod or process (*o*) extending upwards and backwards as far as the outer extremities of the lateral plates. Below, this process is wide and flattened; above, it is cylindrical; and at the point where this change takes place it is obtusely angulated backwards, the whole being a little arched in the same direction. There are apparently two of these great abdominal rods or processes, one belonging to each side, giving support probably to the lower posterior boundary of the abdominal walls and limiting in this direction the naked space above alluded to as extending over the lateral walls of the abdominal chamber. These two stout rods are closely pressed together, and in all the specimens are much confounded with each other.

Above the median line, in front, the outer members of the series of transverse plates and rods are likewise considerably modified. The change takes place gradually, just behind the elevated portion of the dorsal fin. The lateral plates (fig. 3, *g*), however, are only slightly modified; but instead of being united to rods are continued as broad flat plates (*i*), which, inclining forwards, become angulated in front, and then for a short distance (*j*) incline backwards and are united to a series of hour-glass-shaped plates (*k*) that lean in the opposite direction, are extended to the dorsal margin, immediately below the anterior portion of the dorsal fin, and form part of an extended series that reaches to the root of the tail. The broad plate inclining forwards and in continuation of the lateral plates, is undoubtedly a modification of the rod of the posterior part of the body; its margins are abrupt and produced into slightly elevated ridges; and it contracts a little towards its outer extremity, and is slightly thickened at this point. The next portion, which inclines backwards, appears to represent the sigmoidal ridge or plate. The margins of this portion of the series are in contact, and seem to be slightly imbricated; and the outer extremities are turned a little forwards to become united to the external hour-glass-shaped plates.

In the transverse centre of these modified sigmoidal plates there is a ridge (*j''*), similar in appearance to that on the median lozenge-

shaped areas. This upper series of ridges forms a line which extends from the nape, a little above the commencement of the lozenge-shaped areas, and, passing backward parallel to them and about midway between them and the dorsal margin, terminates immediately behind the anterior elongated portion of the dorsal fin. This line of ridges resembles the upper line of mucus-tubes in *Polypterus* ('Poissons Fossiles,' t. ii. pt. 2. p. 50) and in *Dapedius punctatus* (*ibid.* t. ii. p. 192, pl. 25 *a*); and, indeed, in the latter, which in form closely resembles *Dorypterus,* this upper or second lateral line, according to Agassiz, holds relatively exactly the same position.

The marginal hour-glass-shaped plates have their sides abrupt and slightly elevated into ridges. A similar ridge passes along the centre; and the most contracted part of the plate is thickened or elevated, the ends becoming depressed and thin. These peculiar plates, we have said, form a portion of a marginal series (fig. 1, *k*) that reaches to the root of the tail. Behind the anterior or elevated division of the dorsal fin they are much reduced in size, diminishing backwards in length in proportion to the reduced height of the fin, and are not connected with the sigmoidal extremities of the transverse series of plates and rods; neither do their outer extremities appear to articulate with the fin-rays, though there are pretty regularly two rays to each plate. The largest of the hour-glass-shaped plates are $\frac{3}{16}$ of an inch in length. These, in their arrangement and situation, resemble fin-supports.

A similar series of hour-glass-shaped plates extends along the ventral margin immediately within the base of the anal fin, and are large in front for some short distance backwards, corresponding to the space occupied by the enlarged anterior portion of the fin. These large plates and the large ones at the root of the dorsal seem to be articulated with the fin-rays.

The whole of the transverse plates, areas, and rods, as well as the ventral plates and columns and great posterior abdominal rods, seem as if covered with black enamel-like matter, having a semigloss similar in appearance to that which covers the head-bones and fin-rays. Indeed some of them seem as if composed of nothing else; and such is the appearance of a few of the cranial bones themselves. The bony support, however, can be traced in some of them; and a few of the lateral rods are hollow, the bony or cartilaginous support having apparently disappeared. But this enamel-like matter does not seem to have been confined to these parts; it appears to have been continued as a thin film composed of granules between the series of plates, and was extended over the entire surface of the fish as a dermal envelope, the plates and rods being, as it were, immersed in it. Such is the appearance particularly in the region of the sigmoidal ridges, where there is a continuous darkish film of considerable thickness, having a granulated surface and giving the appearance to them of a series of broad continuous plates, which in all probability they are, the grooves in the ridges limiting the anterior and posterior margins of each plate. And there is usually, extending from the margin of the lateral plates, a broken fringe (figs. 2, 3, *v*) of

black matter continuous with that which covers the plates, and which seems to be the remains of the ruptured film or dermal envelope. In fact, in one or two places where the plates are more approximated than usual, the continuity of the connecting film is quite obvious.

Now comes the question, Are the whole of these plates and rods the component parts of an endo-skeleton, or do they partially belong to an exo-skeleton?

At first sight one is disposed to look upon these plates and rods as the remains of an endo-skeleton in a more or less disturbed condition; but on a closer examination a certain difficulty presents itself. There is an element or two too much, that are not found in the usual ichthyic skeleton. The sigmoidal plates and their rods (fig. 1, j, j', i) are additional parts that are very perplexing; had they not existed, there would have been no difficulty in the matter. The lozenge-shaped areas and the lateral plates in that case might have been assumed at once to be a partially ossified vertebral column with the neural and hæmal spines attached, and the hour-glass-shaped plates the fin-supports. But these redundant sigmoidal plates and rods must likewise be taken into account. What are they?

We have to express our indebtedness to Prof. Huxley for an answer to this question.

All the Pycnodonts have supplementary spinous processes, which extend from the vertebral spines to the interspinous processes or fin-supports. The lateral rods, then, in *Dorypterus* would appear to be the homologues of these supplementary spinous processes. Such being the case, the only remaining anomalous feature to be explained is the sigmoidal plates. These, there can be little doubt, are dermal, and consequently do not belong to the endo-skeleton; they are parts of an exo-skeleton, and therefore belong to the same category as the ventral plates, which are assuredly dermal. But this is not so clear with regard to the peculiar compound columns with which the latter are connected, though it would seem evident that the lower portion, which is continuous with the plates, should be so considered. The upper and larger portion, however, of the column, which is composed of numerous elongated rods articulated lengthwise with each other and with the upper prolongation of the plates, probably belongs to the endo-skeleton. These peculiar columns, in their compound structure and twisted appearance, closely resemble similar columns, which are considered to be ribs, in *Pycnodus rhombus*, Ag., and in which they are apparently joined to the vertebræ. In *Dorypterus*, too, the compound columns seem to have their upper extremities united to the lateral plates or neural spines. It would therefore seem probable that in this genus the upper portions at least of the columns are likewise ribs.

The great abdominal rods have a strong resemblance to the bone similarly situated in such fishes as *Vomer*, *Zeus*, and, according to Agassiz's restoration, also *Platysomus*; but in these it seems to be an enlarged development of an interhæmal spinous process; while in *Dorypterus*, in which there appear to be two such rods, they seem

to be developed in connexion with the posterior pair of ventral plates; nevertheless they are probably internal bones.

On the whole, then, it seems pretty clear that these peculiar plates and rods in *Dorypterus* are the component parts of both an endo- and an exo-skeleton. The lozenge-shaped plates or areas are the vertebral centres, or rather the remains of them; the lateral plates are the neural and hæmal spines, and the rods in connexion with them are the supplementary spinous processes; while the hour-glass-shaped plates are the interspinal processes or fin-supports, and the greater portion of the compound thoracic columns are apparently ribs. All these, as well as the great abdominal rods, are component parts of the internal bony skeleton.

The sigmoidal and ventral or thoracic plates, together with the upward prolongation of the latter, forming the basal portion of the compound thoracic columns, seem to be developments of the skin, and consequently belong to an exo-skeleton. The plates, too, that apparently correspond on the shoulder to the sigmoidal plates of the posterior portion of the body, are most likely also dermal; and if so, the ridges in their transverse centre which form a line extending from the nape to some distance down the body are probably true mucus-tubes, which they so much resemble.

There is not much more to say with respect to this matter. We may observe, however, that in *Dorypterus* the ganoid type is modified; and in this interesting form we see, for the first time in the geological series, a true thoracic, or rather a true jugular fish of the Linnean classification; for the ventral fins are considerably in advance of the pectorals, and, indeed, they are placed as far forward as it is possible for them to be. Some change in the body-scales might therefore be expected, though the fins have the usual structure of those of the group to which this fish belongs; and the tail is decidedly heterocercal, with the lobes, which are deeply forked, of nearly equal length. And in the upper lobe there is a double row of the usual rhomboidal scales, resembling in their form and mode of articulation those on the tail of *Acipenser Sturio*, Linn. No other scales are observed on any part of the body of either of the four specimens, unless, indeed, the ventral and sigmoidal plates be so considered. We have, then, in *Dorypterus* a ganoid fish not only deprived of body-scales, but without plates of any kind except those just alluded to.

Having now given the result of a careful examination of all the four specimens at our disposal, collating and rigorously estimating the facts exhibited by each, we shall now give separate descriptions of the specimens themselves, marking emphatically the points for which each is distinguished.

The first specimen (Pl. XLIII. fig. 1) that we shall notice is from the cabinet of our friend Edward Wood, Esq., Richmond, Yorkshire. It is 4 inches long, including the tail, and is about $1\frac{3}{4}$ inch deep at the deepest part. The anterior portion is well preserved. The head is one-third of the entire length of the fish, exclusive of the tail-lobes, and is one-third higher than long; it is arched in front, being

most protuberant at the muzzle; behind, it is angulated near the centre, the posterior margin of the operculum (*s*) determining the form; the jaws (*p*, *q*) are nearly perfect, and are closed, showing that the mouth shuts upwards; the maxilla is wanting, only the impression of it remaining, indicating its form and position. The brow, orbit (*u*), gill-cover, and clavicle (*r*) are all in their natural positions, no considerable disturbance of these parts having taken place.

The pectoral fin (*c*), though in disorder, occupies its proper situation immediately below the angle of the operculum, near the longitudinal centre; and one of the ventral fins (*d*) is well displayed at the ventral margin in connexion with the lower extremity of the clavicle. It is narrow, and its pointed extremity inclines backwards as far as the posterior extremity of the second ventral or thoracic plate; it is upwards of half an inch in length. Little more than half an inch remains of the elongated portion of the dorsal fin (*a*); and mere traces are perceptible of the narrow posterior division. The narrow backward portion of the anal fin is scarcely distinguishable; but the large anterior member (*b*), though not entire, is distinct about the middle of the ventral margin and a little behind the ventral plates. The tail-fin is almost perfect, exhibiting both the general outline with the lobes spread and the surface-characters. The upper lobe, which is a little longer than the under, is about an inch long.

The transverse series of plates and rods are much disturbed over the whole surface, though in places they are partially in order and show the same surface-characters as are displayed in specimens in which these parts are more perfect; and, as in them, they are covered with black enamel-like matter. The ventral plates (*m*), however, are arranged in complete order along the ventral margin, from the base of the ventral fin to a little in front of the anal, overlying each other apparently forwards; but on closer examination they are seen to imbricate backwards, and to give off from their upper extremities the peculiar compound columns (*n*) already described, which, extending upwards in parallel order, incline towards the head. The anterior ones are the shortest, and appear to terminate near to the margin of the clavicle. A few of the posterior pass above the angle of the operculum and can be seen to join with the lateral plates of this region, notwithstanding that they are much disturbed. The large posterior abdominal rods (*o*) occupy their usual position, sloping backwards from the last ventral plate.

The specimen (Pl. XLIII. fig. 2) next to be described is highly instructive, though it is in many parts much disarranged. The head, in particular, has greatly suffered, the upper margin being entirely obscured by the opercula (*s*), which have been torn from their natural positions and turned upwards and forwards; their lower extremities are placed close together, and project in front of the brow. They lie with the external surface uppermost, their anterior margins approximating. That belonging to the right side has carried along with it the pectoral fin (*c*), which is beautifully displayed, in an expanded state, almost complete. The left pectoral is distinctly seen in its natural position, though much injured, and overlain by a thin film of

apparently the skin. The mandibles are not disturbed, and by their position indicate that the mouth was closed; but the bones of the upper jaws are not determinable, except the left maxilla, which is in a pretty perfect state; the præmaxilla, however, has been torn away. The orbit (u) is pretty well preserved, but is removed a little below the natural position.

The contour of the dorsal margin, in front of the dorsal fin, is entirely lost, this region having been forced downwards nearly as far as the centre of the body. Posteriorly, however, the whole form is well preserved, and exhibits the transverse plates and rods in a good state of preservation, the series of lateral (g) and sigmoidal plates (j) being almost complete; the line of the central lozenge-shaped plates (h) is also quite distinct, with a plate here and there bearing a central ridge. In front this line is thrown suddenly upwards, in consequence of the ruptured condition of the anterior parts. Twenty-eight lateral plates can be counted, and fifteen or sixteen sigmoidal ones along the lower margin; only ten or eleven can be made out of the dorsal row.

One of the most interesting features in this specimen is the ventral plates (m), which are displayed in a remarkable manner. Without the aid of this specimen it might have been difficult to determine the existence of a double series of these plates, one belonging to each side of the abdomen. Here, however, both sets are most satisfactorily seen, those belonging to the exposed, or left side, being arranged in their natural order, while those of the right side are turned downwards below the ventral margin, so that their outer surface is placed upwards and in the same plane with the similar aspect of the other plates. The lower margins of the two sets are in close contact, the line of junction coinciding with the ventral margin. The plates in both series incline forwards, their pointed extremities being turned backwards; and the compound columns (n) in connexion with the upper extremities are distinctly displayed, those belonging to the left side taking their usual course upwards in the direction of the head and lozenge-shaped area, those on the right side, or those of the displaced series, passing outwards from the specimen, the columns, like the plates themselves, having been displaced and thrown downwards. And thus we have a satisfactory proof that both the ventral plates and columns are developed in two lateral and distinct series. And furthermore these columns are seen, in the specimen before us, to pass upwards and to become united to the lower anterior lateral plates, notwithstanding that they are much disturbed at this point.

The dorsal fin (a) has been broken away, only three-quarters of an inch remaining. The anterior basal extension, however, is well shown, as this portion is turned a little towards the observer and has been forced downwards. Consequently the short anterior basal plates, or fin-fulcra (a''), are seen to be arranged in a bilateral series of about twelve. This bilateral arrangement of the fin-fulcra is not, we believe, usual among the ganoids, in which the two lateral halves are commonly united into one piece. Mere traces are observable

of the narrow posterior extension of the fin, though the marginal hour-glass-shaped plates are regularly disposed immediately within the posterior slope. Nothing is to be seen of the anal fin, except the base of the anterior portion, at which point the hour-glass-shaped plates are distinctly displayed; and traces of them are visible almost to the tail. The remains of both ventral fins (*d*) are traceable immediately in front of the ventral plates, over the anterior of which one of them is spread, the rays being directed backwards.

The tail is admirably shown, and is exceedingly perfect. The lobes are expanded, exhibiting the depth of the bifurcation. The marginal fulcra, plates or scales (*f*), and the double row of rhombiform scales (*e*) behind, as well as the fin-rays of both divisions, are very perfect, the latter displaying their bifurcated extremities stretched out. The lobes are about equal in length, if measured from the root, along the axis. In this way they are $1\frac{1}{4}$ inch in length; but if measured along the posterior margin, the upper lobe is nearly $1\frac{1}{4}$ inch long, and the under lobe only $\frac{7}{8}$ of an inch in length. The width of the tail from tip to tip is upwards of $1\frac{3}{4}$ inch. The specimen measures $4\frac{3}{4}$ inches in length, and $1\frac{7}{8}$ inch in depth. This specimen remains in the possession of Mr. Duff, to whom we are indebted for the discovery of these and many other interesting fossil remains.

Our third specimen (Pl. XLIII. fig. 3) is the only one which lies with its right side exposed; all the other three have the left side uppermost. This measures in length, including the tail and making allowance for what is wanting in front, $4\frac{3}{4}$ inches, and in depth at the widest part $2\frac{1}{8}$ inches; and it is chiefly distinguished by the large portion that remains of the dorsal fin.

The head does not appear to have been much injured when the specimen was deposited; but unfortunately the upper and frontal portions are broken away. The orbit (*u*), however, is well marked; and so are the boundaries of the opercula (*s*), the posterior contours of which are quite distinct. Three or four of the ventral plates (*m*) are seen in their proper places in front of the anal fin, sending upwards their columns, which exhibit well their compound and twisted appearance. Some of them reach the lateral plates near the occiput. The great abdominal rods (*o*) are seen in connexion with the posterior plate inclining upwards and backwards.

The plates and rods are much displaced; but, notwithstanding, their connexions and characters are in some places well seen, particularly the relationship of the lateral plates to the lozenge-shaped central plates, or areas, on a few of which the median ridge is quite distinct, and the continuity of the dark enamel-like surface-matter with that covering the lateral plates is very obvious.

Considerably more of the dorsal fin (*a*) is present than in any of the other specimens. One inch and three-quarters of it, in a good state of preservation, inclines backwards; and in front, arranged in exact order, are twelve or thirteen short plates, the fin-fulcra (*a''*); but these so imperceptibly graduate into the regular rays that it is difficult to determine the exact number; they are strong, pointed, and have the root distinctly rounded. The broken extremity of the fin

is a little less than $\frac{2}{10}$ of an inch wide; and from this we infer that more than one-half of this fin is wanting. In this specimen it would probably be a little short of 4 inches long. There are twenty-four or twenty-five rays at the base of this elongated portion, including the short anterior plates or fulcra; and $1\frac{1}{2}$ inch up only seven or eight can be counted. Very little is to be seen of the narrow posterior portion of the fin, there being only a slight trace of a few rays.

The pectoral fins (*c*) are in a pretty perfect condition, occupying their natural position immediately behind the posterior angle of the gill-covers, one partially overlying the other. At the root of one of them there are two flat curved bones, which may perhaps be respectively the scapula and coracoid. Arising from these are the brachials (*c′*), to the number of fourteen or fifteen; they are about $\frac{1}{8}$ of an inch long, and are delicate and flat, thicker than the fin-rays, with the extremities obtuse; and there are two simple rays, composed of many joints, to each brachial.

The remains of both the ventral fins (*d*) are seen in front of the ventral plates, the edge of the belly being turned a little upwards. Two elongated bones, nearly $\frac{1}{4}$ of an inch long, lie in contact with them, and have their anterior ends a little enlarged and nodulous. These are probably the pelvic bones, to which the fins were attached, the thickened extremities having all the appearance of articular surfaces. The mere casts of these bones are observed in connexion with the specimen; but the bones themselves are present on a fragment of the slab that was split off from the specimen.

The enlarged portion of the anal fin (*b*) is pretty well displayed, immediately behind the ventral plates; but the narrow posterior part is scarcely traceable.

The tail is well developed; but half of the upper lobe is wanting. The under lobe shows distinctly the numerous short joints of which the rays are composed, as well as their terminal bifurcations. This lobe is $1\frac{1}{2}$ inch long. The scales (*e*) and marginal plates, or fulcra (*f*), are well preserved on the upper lobe.

The last specimen (Pl. XLIII. fig. 4) we have to describe is the largest of the four; it is 5 inches in length and $2\frac{1}{4}$ inches deep. The head is much crushed; but the orbit (*u*), the narrow elongated gill-plates (*s*), and jaws (*p*, *q*) are all determinable, though much injured. The ventral plates are confused and broken; they occupy, however, their natural position; and a few of the compound columns are present and can be traced to the anterior lateral plates. The great abdominal rods (*o*) are also conspicuous, inclining backwards, the lower wide extremities in contact with the last ventral plate and the upper extremities leaning against and, as it were, pushing backwards the lateral plates in the immediate vicinity of the abdomen.

The lateral plates (*g*) and rods (*i*) are well preserved; and the series of lozenge-shaped areas (*h*) form a distinct line from end to end, displaying better than any of the other examples the elevated central ridges. The plates on the shoulder (*j′*) are also beautifully preserved in regular order, and exhibit, in great perfection, the ridges resembling mucus-tubes; and the whole series of the sig-

moidal plates (j), with their rods (i), along the ventral margin, can be determined; and some of them are in good condition. The hour-glass-shaped plates (k) are quite distinct, and are regularly arranged along the same margin; and those below the elevated portion of the dorsal fin are likewise in excellent order.

No distinct traces of either the pectoral or ventral fins are left. The dorsal fin (a), too, is very imperfect, $\frac{3}{4}$ of an inch only remaining. The short anterior plates, or fulcra (a''), are pretty distinct; but the merest traces are found of the narrow posterior part. The greater portion of the anterior division of the anal fin (b) is well preserved, and the narrow posterior part (b') is determinable throughout its length. The tail is much injured, but lies, as in all the other examples, spread out, the two lobes being strongly defined.

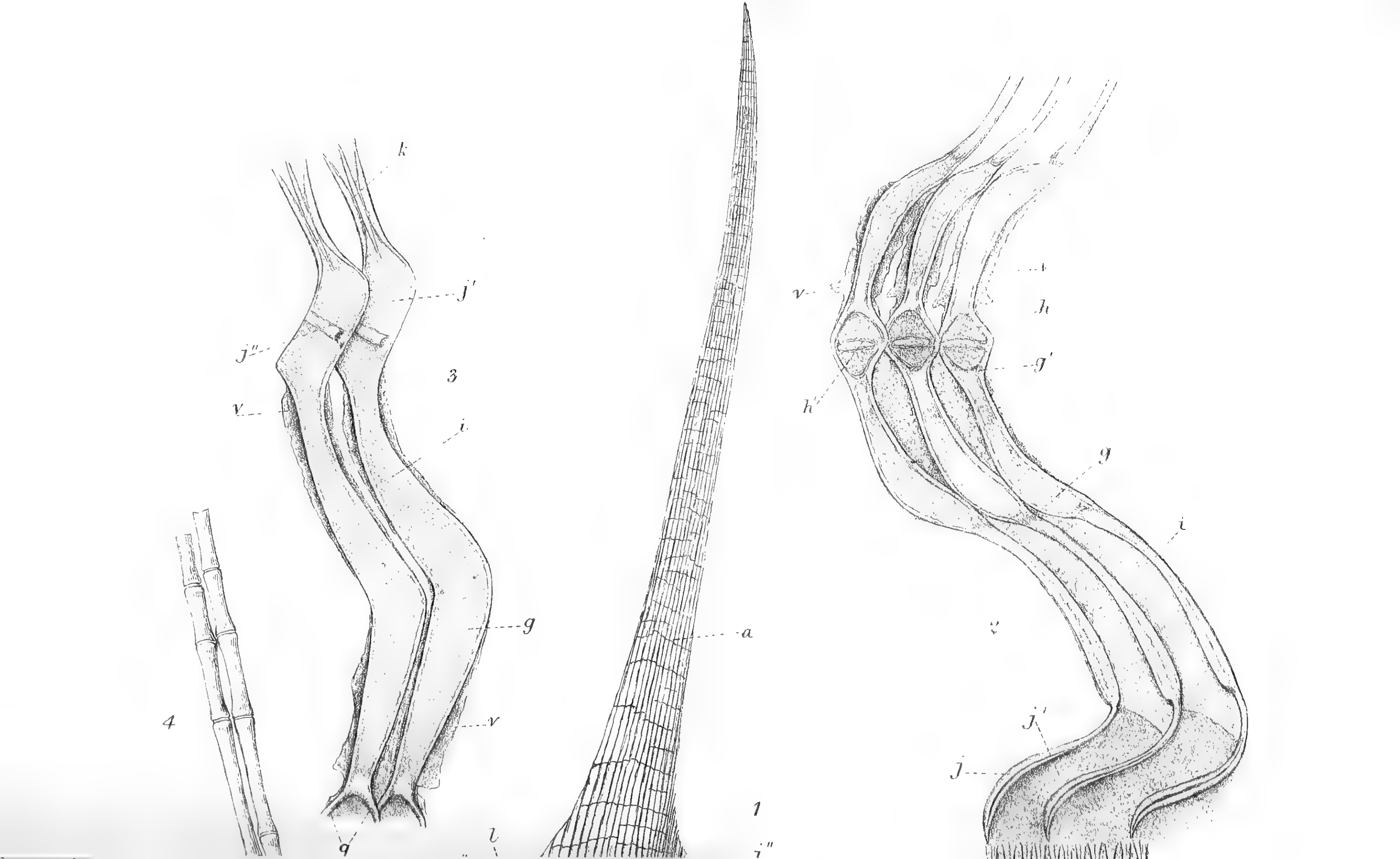
We have now only a few concluding words to say as to the place this curious fish should occupy in the classification. We know of no family with which it can be associated, though it undoubtedly is closely allied to the Pycnodonts; and of these perhaps it approaches most closely to *Gyrodus* and *Microdon*: but while in *Dorypterus* the head-bones are smooth, they are in most of the Pycnodonts granulated or otherwise ornamented; and our fish likewise differs from them in the absence of the usual body-scales.

The large and upward-shutting mouth, too, is not found in the Pycnodonts; and the apparent absence of the strong characteristic teeth of that group is noteworthy. Had such teeth existed in the fish under discussion, some trace of them would assuredly have been observed, since we have seen that the jaws are pretty well preserved in two or three of our specimens. It is probable therefore that the dental organs were small and inconspicuous, if they existed at all. The enormous development of the dorsal fin and the forward position of the ventrals are significant facts. The latter is particularly worthy of notice, especially when we consider that we have in this palæozoic species the earliest thoracic fish known in the geological series. And further Sir Philip Egerton states, in a letter with which he has lately favoured us, that he "is not cognizant of any fish in strata older than the chalk having the fins thoracic or jugular." On the whole, then, we confess ourselves at a loss to determine where to locate *Dorypterus* in the system. Is it not the representative of a distinct family having a certain relationship to the Pycnodonts? This we must leave for the determination of those more conversant with ichthyology than we ourselves are.

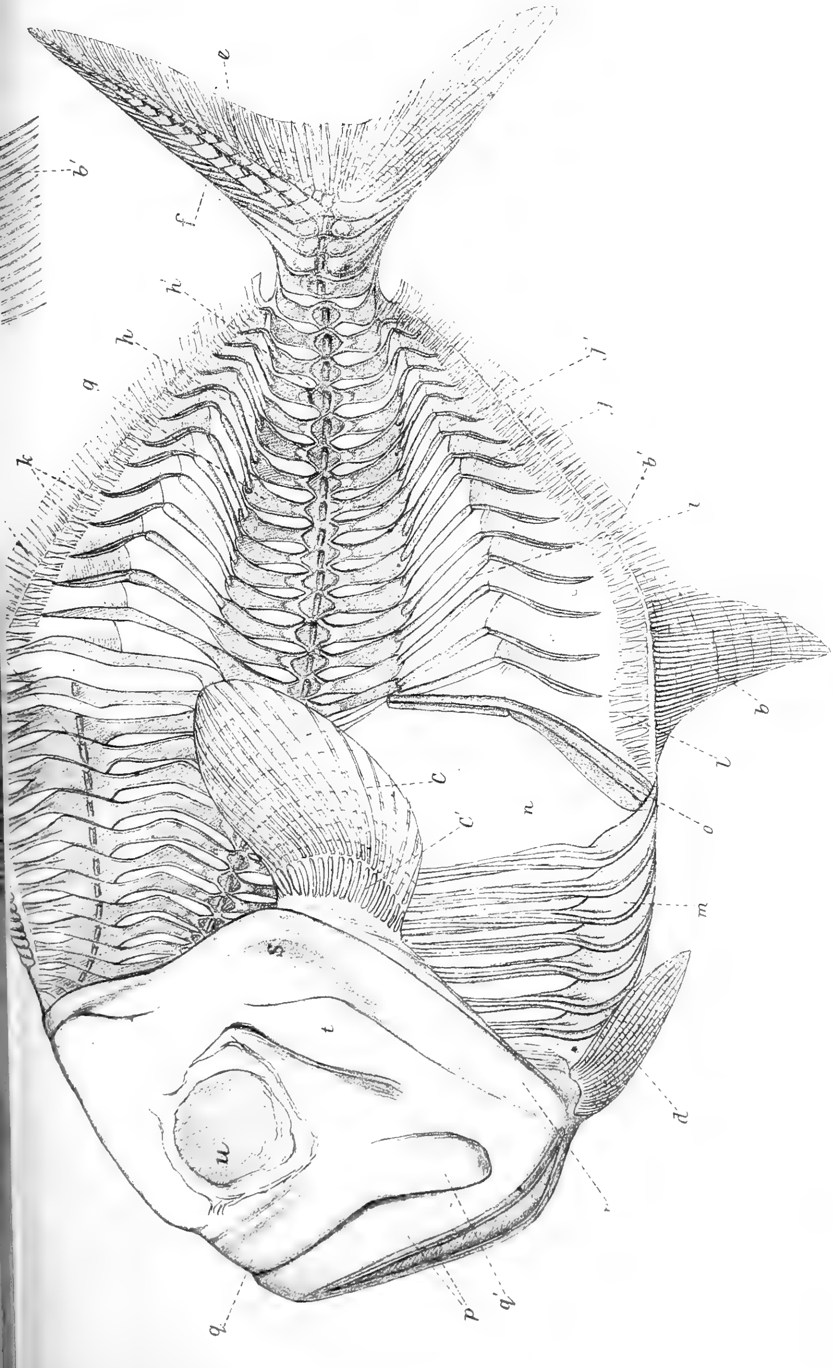
EXPLANATION OF PLATES.

The following letters apply to all the figures of *Horypterus Hoffmanni*.

a, dorsal fin; *a'*, narrow posterior prolongation of ditto; *a''*, anterior prolongation, or fin-fulcra of ditto; *b*, anal fin; *b'*, posterior, narrow prolongation of ditto; *c*, pectoral fins; *c'*, brachial rays; *d*, ventral fins; *e*, rhombiform scales of tail; *f*, fin-fulcra of ditto; *g*, lateral plates or vertebral spines; *g'*, bifurcation of the inner extremity of ditto; *h*, lozenge-shaped plates, or areas,—the vertebral centres; *h'*, ridge in the centre of ditto; *i*, rods, or supplementary vertebral spines, in connexion with the lateral plates; *j*, sigmoidal ridges; *j'*, sig-



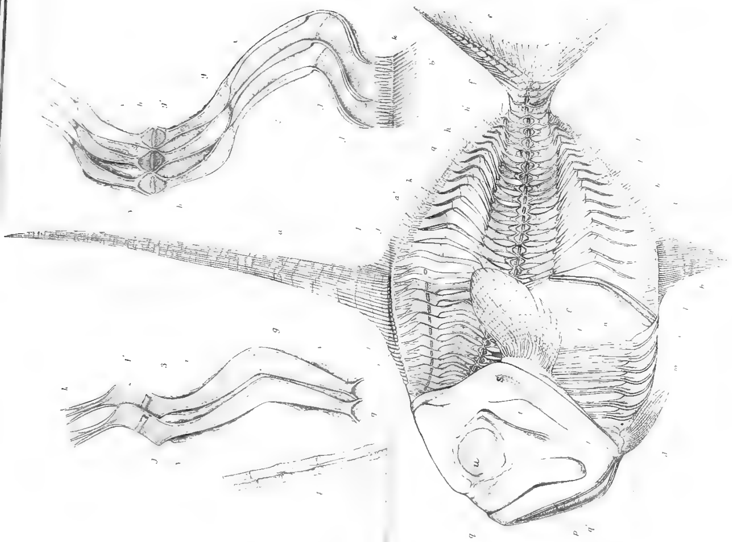
k
j'
j''
3
v
i
g
4
v
q
l
a
1
j''
v
h
g'
h'
g
i
j'
j

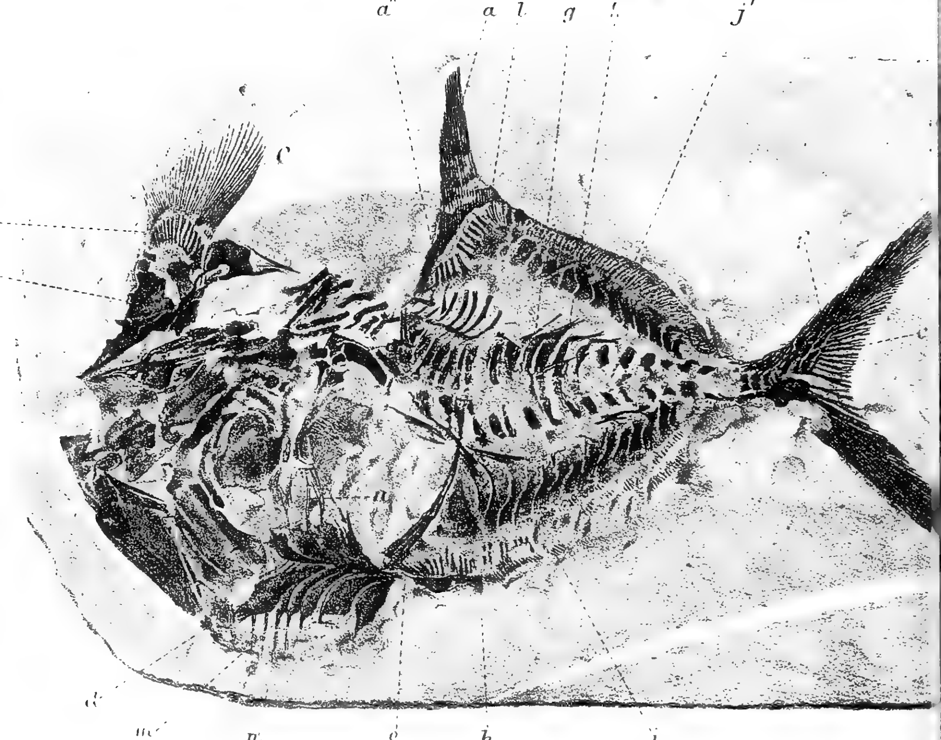


RESTORATION OF DORYPTERUS HOFFMANNI.

A. Hancock del. G. W. ... lith.

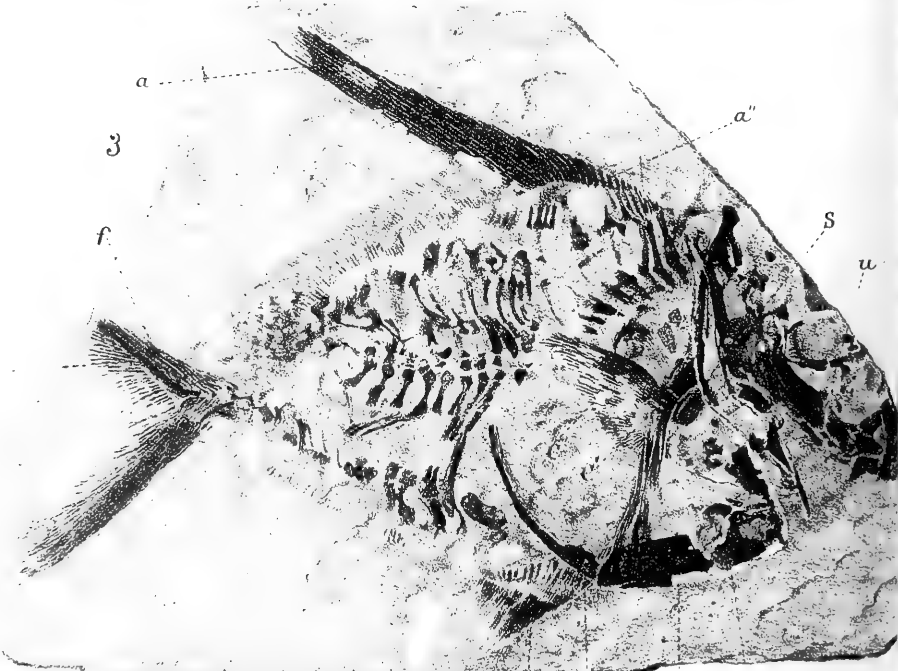
Mintern Bros. imp.



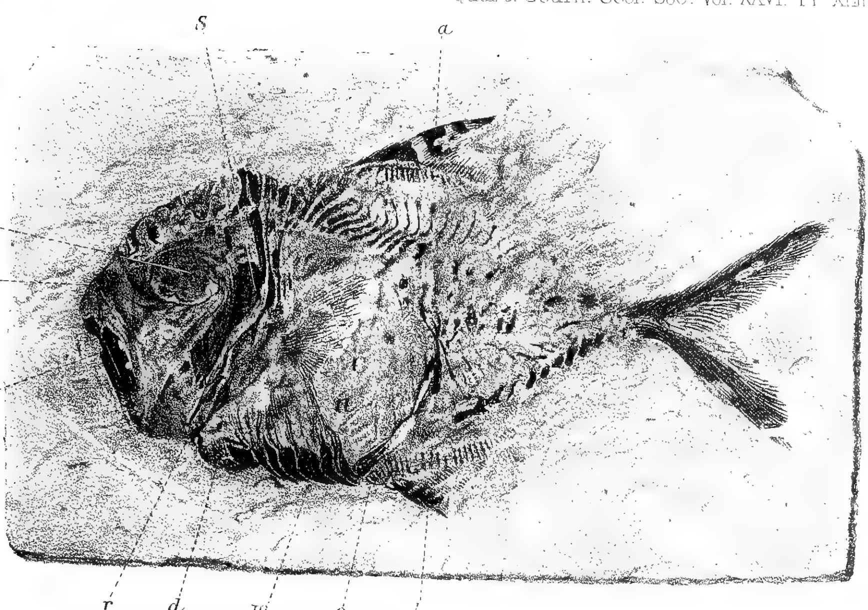


2

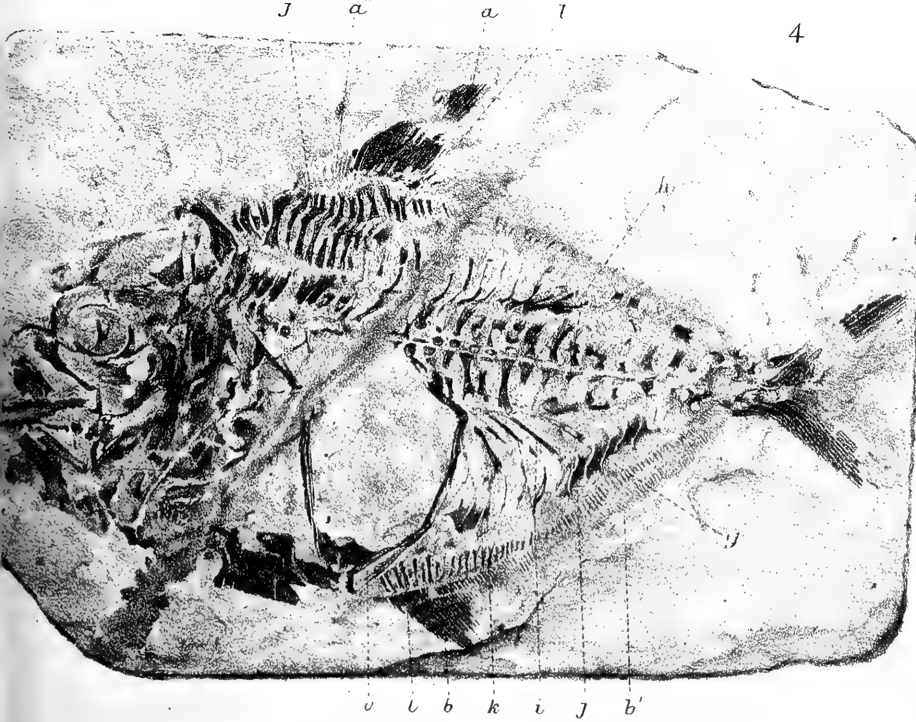
3



DORYPTE



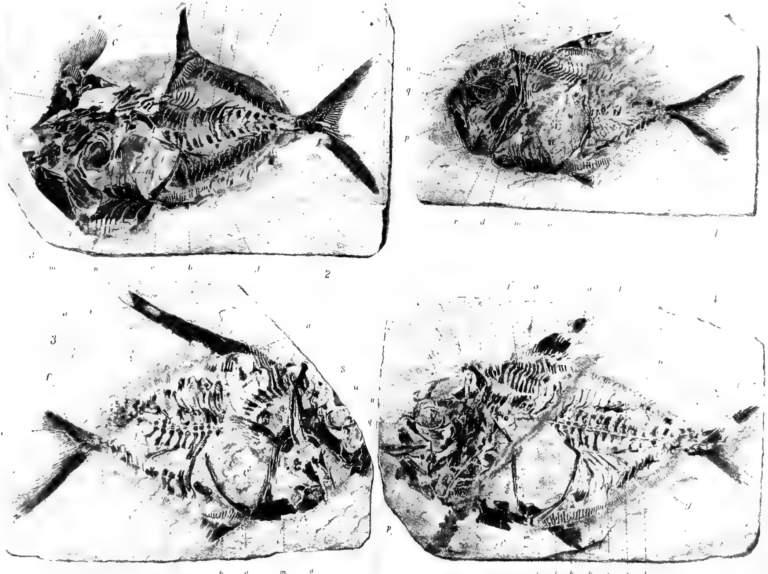
1



4

IOFMANNI.

Mintern Bros imp



G. H. Ford CRYPTERUS HOFMANNI

moidal plates; j'', ridge or mucus-tube in the centre of ditto; *k*, hour-glass-shaped plates or fin-supports; *l*, large ditto at the base of the dorsal and anal fins; *m*, ventral or thoracic plates; *n*, compound columns in connexion with ditto; *o*, great abdominal rods; *p*, mandibles; *q*, præmaxilla; q', maxilla; *r*, clavicle; *s*, operculum; *t*, præoperculum; *u*, orbit; *v*, fragments of dark granular matter, apparently dermal.

Plate XLII.

Fig. 1. General view of the restored skeleton of *Dorypterus Hoffmanni*.
Fig. 2. Much enlarged view of three of the transverse rods and plates.
Fig. 3. Much enlarged view of two of the plates and rods on the shoulder.
Fig. 4. Portion of two rays of the dorsal fin, showing the joints.

Plate XLIII.

Fig. 1. Specimen of *Dorypterus Hoffmanni*, exhibiting the head, ventral plates, and ventral fin in good order.
Fig. 2. Another specimen, exhibiting the tail, pectoral fins, base of dorsal fin, gill-covers, ventral plates, the skin, and the various plates and rods.
Fig. 3. Specimen of *Dorypterus Hoffmanni*, exhibiting the dorsal fin, pectoral fins, and lateral plates with the lozenge-shaped areas and ridges or mucus-tubes.
Fig. 4. Specimen of *Dorypterus Hoffmanni*, exhibiting the dermal plates with the lozenge-shaped areas and ridges or mucus-tubes, particularly the plates on the shoulder with the upper line of ridges or mucus-tubes.

---

6. *On the* Glacial Phenomena *of* Western Lancashire *and* Cheshire. By C. E. De Rance, Esq., F.G.S., of the Geological Survey of England and Wales*.

The first notice of any importance of the drifts of Western Lancashire was made in 1832, by Sir Roderick Murchison, who described the occurrence of sands and gravels with marine shells in the neighbourhood of Preston†.

In 1837, the Rev. W. Thornber described the sands and gravels of Blackpool as containing more than 20 species of marine shells‡. These sands have since proved to be of the same age as those of Preston, and to belong to the middle drift.

In 1841, Mr. Binney published his classification of the drifts around Manchester, which he divided as follows:—

Recent	*a.* Valley-gravels and River-terraces.
Drift	*b.* Forest Sand, of Kersal Moor, &c.
	c. Till, or Boulder-clay.
	d. Sand, generally local.

This order he adopts in his "Notes on the Lancashire and Cheshire drifts"§, read in 1842; and he adapts the same classification, to a certain extent, to the cliff section at Blackpool in his "Notes on the Drift Deposits near Blackpool"‖, read in 1852.

* Communicated with the permission of the Director-General.
† Report of the Brit. Assoc. 1832.
‡ History of Blackpool.
§ Trans. Man. Lit. & Phil. Soc. vol. vii. (new series), p. 204.
‖ *Ibid*, vol. x. p. 123.

In 1846, Prof. E. Forbes published the names of certain shells he had found in the Lancashire drift, amongst others a *Dentalium* from Preston*.

In 1862, Mr. Hull† described the results of the mapping of 600 square miles of drift around Manchester, which necessitated a modification of Mr. Binney's classification, a Boulder-clay resting on the upper sand and gravel, and the lower sand and gravel being often absent.

RECENT	Valley-gravels and River-terraces.
DRIFT	Upper Till, or Boulder-clay. Middle Sand and Gravel. Lower Till, or Boulder-clay.

FORM OF THE GROUND IN WESTERN LANCASHIRE AND CHESHIRE.

Undulating plains (of Triassic and Upper Carboniferous rocks), more or less covered with glacial drift, occupy the country between Liverpool and Chorley, westward of which a low plain covered with peat-moss borders the sea-coast.

Between Chorley and Lancaster the rock surface is extremely low, often, indeed, beneath the sea-level; but beds of glacial drift, often 150 feet in thickness, are piled up on it, forming a slightly inclined plane, dipping from the Pendle range towards the sea, where it forms a line of cliffs near Blackpool from 40 to 80 feet in height. This drift plain has been cut through, to a greater or less extent, by various brooks, streams, and rivers. Few, however, have reached the rock surface beneath, the Ribble and its tributary the Darwen being almost the only exceptions.

The third area into which Western Lancashire and Cheshire may be divided consists of three extremely low tracts, in which not only the rock surface, as in the Preston district, lies below high-water mark, but in which the glacial drifts themselves have been denuded away, so that the sea has to be kept out by sea-walls and banks, and is daily making encroachments. They are all areas of former obstructed, and present artificial drainage, and are deeply covered with peat-moss, which reaches in one instance a thickness of 30 feet. The first district is the low country between Lancaster and Fleetwood, lying on both sides of the river Wyre; the second stretches from the river Alt, north of Liverpool, to the river Douglas, north of Southport; and the third lies between the rivers Dee and Mersey, in that part of Cheshire known as the peninsula of Wirral. It is traversed by a small stream, called the Birket, falling into Wallasey Pool‡, a tributary of the Mersey, and bounded to the south by an escarpment hereafter to be described.

* Mem. Geol. Survey, vol. i.

† Trans. Man. Lit. & Phil. Soc. vol. ii. (3rd series), p. 451. Mem. Geol. Sur., Country around Oldham, 1864.

‡ *Pool*, in this district, is synonymous with "brook;" thus Bromborough *Pool*, Liver*pool*, Black*pool*.

Glacial Deposits of Western Cheshire and Lancashire.

Lower Boulder-clay.—This bed, in North Cheshire, between Liverpool and Southport, and between that town and Preston, is a soft rather loose clay, of a reddish-brown colour, containing many erratic boulders and pebbles, nearly all of which are ice-scratched, but rounded by marine action. It occasionally contains seams of sand and beds of marl, the latter being much used for marling the moss lands near Halsall, Crosby, Formby, and Southport.

When the Lower and Upper Boulder-clays are seen in the same section in the districts mentioned above, as at Egremont, in Wirral, and near Preston, the two clays are found to be apparently identical, both as regards physical aspect and the character of the included fragments. But in the Lower Boulder-clay of Blackpool, and to a greater extent in that of the Furness district, known as "pinel," a slight change of character takes place: the stones are more closely packed, each individual stone is scratched in every possible direction, and the percentage of granites and Lake-district Silurian erratics increases. These clays lie in boss-shaped masses beneath the Middle-drift sand and gravel, as if shot down in the water by a moving body from above; the pebbles in the clay, though so intensely scratched, are nearly all waterworn; and fragments of the rocks beneath the drift at Blackpool are absolutely never found. It therefore appears probable that a fringe of coast-ice skirted the foot of the Lake mountains, which, lifted daily by the tides of the glacial sea, scratched the pebbles of the beach (formed by the sea before the coast-ice came into existence), in every possible direction, and that these, when the ice was carried out into the more open sea by tidal currents, were deposited in the tumultuous heaps of packed silt which we observe in various parts of the Lancashire lowlands. I may here mention that I found shells of the species of *Tellina balthica* and *Turritella communis* in tolerably good condition in the Lower Boulder-clay of the Blackpool section.

In a railway-cutting made last year between Chorley and Blackburn, the Upper Boulder-clay and Middle Drift were seen resting on a stiff clay of a bluish-black colour, containing rather angular blocks of comparatively local origin, the clay being of such extreme hardness as to seriously affect the cost of the work, damaging the tools of the men, and withstanding the action of blasting. Since examining this section, to which I have had the pleasure of directing the attention of Mr. Eccles, F.G.S., and my colleague Mr. Tiddeman, F.G.S., I have found other examples of this peculiar type of Lower Boulder-clay; and in some cases the ordinary marine Lower Boulder-clay is seen resting on an *eroded* surface of the stiff blue clay beneath, which I believe to have been formed by land-ice, probably in the form of an ice-sheet. I have never yet found in it either Lake-district erratics, granite boulders, or marine shells; and from a careful examination of the drift-deposits of the Lake-district, I believe this "terrestrial Lower Boulder-clay" to have been formed contemporaneously with the Lower Moraine Drift of that area, and that both are in great measure older deposits than the marine Lower Boulder-clay.

Lower Boulder-clay has been described by two observers as resembling the Upper Till at great elevations on the Penine Chain; but on further examination, it may possibly be found that the clay in these instances belongs to the upper division. I myself have never found any marine Lower Boulder-clay above an elevation of one hundred and fifty feet; and I believe that the glacial sea, in the Lancashire lowlands, had only a depth of about twenty-five fathoms at the close of the period of its deposition.

Fine sections of this Boulder-clay are exhibited in the cliffs of the Ribble, above Preston, especially at Red Scar and Balderstone, at which latter place the section was first described* by Prof. E. Hull in 1867; and I had the pleasure of showing it to Mr. Mackintosh in the spring of last year.

Middle Drift.—The sand and gravel of the Middle Drift rests upon a slightly undulating inclined plane of Lower Boulder-clay, dipping from the hills of the Penine Chain towards the valley of the Mersey at Manchester, and towards the sea in the country to the west—no doubt owing to its being a plane of deposition on a sloping sea-bottom, as suggested by Prof. Ramsay to Mr. Hull, to account for a similar phenomenon in the Manchester district†—these hills, like the mountains of the Lake-district, forming islands in the Lower Boulder-clay sea.

The Middle-drift sand is well seen in the cliff at Codling Gap, near Egremont, in Wirral, where about 70 feet of Lower Boulder-clay occurs between it and the underlying pebble-beds of the Bunter Sandstone, with about the same thickness of Upper Till above; and at the side of it the sand is much current-bedded and is extremely fine-grained, has almost to resemble the Fox-mould of the south-west of England; it contains a fair number of pebbles, all of which are rounded, but none scratched. These generally lie in the lines of current-bedding, as is the case with the pebbles in the Triassic Pebble-beds of the district. The sand in this section is only about 20 feet in thickness, and may almost be said to be intercalated in the Boulder-clay. The rock surface here is a little below high-water mark, extending under the drift to an early, or preglacial cliff, probably about 600 yards inland at Egremont. This approaches the river and the sea at New Brighton, and forms the existing line of sea-cliff there, culminating in the well known picturesque cliff called the "Red Noses," soon after which the rock is lost sight of under a range of sand dunes.

In the Lower Boulder-clay of Codling Gap I found a shell of *Turritella communis*; and Mr. Morton records the occurrence of that shell and *Mya truncata* in the Lower Boulder-clay of Liverpool‡.

On crossing the river Mersey from Liverpool to Seacombe, and ascending the hill upon which the village of Liscard is built, the peninsula of Wirral is seen to be divided in two by a deep narrow gorge, at the bottom of which flows Wallasey Pool. This river, now

* Trans. Man. Lit. & Phil. Soc. vol. vi. 3rd series.

† *Ibid.* vol. ii, 3rd series.

‡ Geology of Liverpool, p. 15.

a tributary of the Mersey, can be proved historically to have been once the chief estuary of that river. The southern bank of this gorge extends westward to the river Dee, forming an abrupt termination to the various ranges of hill and valley, which, coinciding with the strike of the component Triassic rocks, run in a series of north and south parallels. Most of these valleys are traversed by faults, also running in a northerly direction, which, generally throwing hard rocks against soft, have caused the initiation of the lines of denudation of the latter, the soft Keuper marls and upper mottled sandstones being denuded away, while the hard beds of the Keuper sandstone and Bunter pebble-beds form long lines of escarpment, whose steepest sides face the western gales. This, however, as has been pointed out by Mr. Hull, is the characteristic feature of the Triassic scenery of this part of England.

With the exception of the crests of a few of the highest hills, the whole district is covered with glacial deposits—the slopes of the hills, equally with the bottoms of the valleys and plains, and even the bed of the Mersey itself.

The low cliffs of Triassic pebble-beds between Eastham and the mouth of Bromborough Pool are capped with a thin coating of glacial deposits; at one point the Upper Boulder-clay is seen resting on some sand, which appears to represent the middle drift, about three feet in thickness, resting directly upon the rock, the Lower Boulder-clay being absent. On the Lancashire side of the river, opposite Eastham, the glacial deposits come down to the level of the beach; it will therefore be seen that the cliff on the south (or Cheshire) side of the river, capped with drift, must have been formed since the glacial epoch, the river now flowing through an old preglacial valley since filled up with glacial *débris* and reexcavated by the present river Mersey.

The Middle-drift sand at Egremont thins out in the direction of Liscard, probably terminating against the concealed cliff, or, to speak more correctly, the slope of the old valley. No Boulder-drift appears to be found in the bed of the Mersey between Egremont and Liverpool; and the rocks form a low terrace in the lower part of the town; indeed a portion of it is reclaimed from the river itself. In this low district, however, certain postglacial deposits occur, hereafter to be described. These are about 20 feet thick, and rest directly upon the rock.

I have described the marine Lower Boulder-clay as probably formed in water of a maximum depth of about twenty-five fathoms, in unequal heaps of deposition, upon a sloping sea-bottom—its surface, below the base of the Middle Drift, rising from 5 to 15 feet per mile from the sea towards the watershed. On its surface the Middle Drift is piled up to a thickness often of 60 and even 70 feet; but at elevations of about 300 feet above the sea it generally rests upon rock, above that occasionally on the stiff blue-coloured Lower Boulder-clay. It is chiefly composed of sand, with beds of gravel dovetailed, so to speak, into the mass. The gravels are much current-bedded, apparently by a current moving from the north-west to the

south-east. These gravels are well seen in the Blackpool section, in the Ribble Cliffs at Red Scar and Balderstone, and in pits near Leyland and Chorley. Shells more or less perfect are invariably found associated with these gravels; and in those of Leyland I obtained some bones of an herbivorous mammal, which, however, were too fragmentary for Mr. Boyd Dawkins, F.R.S., who kindly examined them, to identify the species.

The pebbles in those gravels are all rounded, and are chiefly from the Lake-district; at Leyland and Chorley, carboniferous rocks and blocks of coal form about 12 per cent. of the larger blocks. With few exceptions, these pebbles are never scratched; and both the character of the beds, and the species of Mollusca found in them, testify to the great amelioration of the climate which ensued during the Middle-drift period; this, however, from Mr. Croll's calculations, is only what might be expected.

In the instances where scratched pebbles occur, especially at Samelsbury, the sand is not the clean fine sand usually found in the Middle Drift, but has a loamy, or even clayey, character. This seems to point to special physical conditions; and it appears not improbable that during this warm episode in the Glacial epoch stray icebergs from regions still further north, or from hills cold from their elevation, floated occasionally from the north-west to the south-east in the Middle-drift sea.

Beds of loam varying in thickness from 1 inch to 3 feet occur in the Middle Drift; and some of them are much used as sand for brass-casting. They generally have a slight dip to the E.S.E. These, from having a certain amount of clay in their composition, support small sheets of water, which, becoming charged with carbonate of lime, often consolidate the surface of the loams into a substance as hard as rock. This also takes place under exceptional circumstances in the gravel-beds, producing masses of conglomerate resembling that portion of the Millstone Grit known as the Kinderscout Grit. These are seen in various places in the banks of the Ribble and in the Blackpool cliffs, where they are used to form rockwork, which has already been described by Mr. Mackintosh in his paper before referred to. In many of the deep-brook valleys in the Preston district the Middle Drift occupies the sides, and the Upper Boulder-clay the top, being separated from one another by a seam of this consolidated loam. These seams often run for miles without a break, though not more than three inches in thickness.

The level of the top of the Middle Drift is an exceedingly variable quantity, varying 60 and 70 feet in half a mile, but it invariably dips from the hills of the Penine Chain towards the sea and the low country. At Blackpool it is 80 feet above the level of the sea, at Chorley 275, at Leyland 150; and Mr. Hull gives the elevation of the base of the Upper Boulder-clay in "the valley which runs up from Manchester by Bolton to beyond Sharples," as 275 feet above the sea at Pendlebury, at Clifton 285, at Kearsley 300, at Halshaw Moor 285, opposite Burden Bridge 300, at Bolton 300, and

so on, rising to an elevation of 500 feet at Dunsear Bridge, being 225 feet in about nine miles, or at the rate of 25 feet per mile *.

It has already been remarked that in the Preston district the Middle Drift is generally found outcropping along the sides of the deep-brook valleys, and capped by Upper Boulder-clay; in addition to this it is occasionally found capping the tops of hills of various elevations, generally at far higher levels than in the banks of the adjoining brooks. When these patches of sand are examined, they are found not to be, as might be supposed, outliers of a sheet of Middle Drift once overspreading the country and resting upon the Upper Boulder-clay, but, on the contrary, they are "inliers" coming up through the Upper Till, forming knolls often of considerable elevation. But in addition to this the sand and gravel are found to form knolls, so to speak, under the surface of the Upper Boulder-clay; or, in other words, the surface of the Middle Drift is a series of rolls and hollows filled in and covered up with Upper Boulder-clay, since denuded into other hills and valleys, which occasionally follow the old lines of hollows of the Middle Drift, in which case we have the latter at the top of the plain and the Upper Boulder-clay extending right down to the bottom of the valley, 50 or 60 feet beneath it. The level of the top of each knoll of Middle Drift, whether at the surface or found in pits or borings beneath the Boulder-clay, is found to dip steadily towards the west and south-west; and the top of each is flattened, resembling in form a truncated dome.

When examining the very large sandbanks in the estuary of the Ribble, which are forming at the present time, I was much struck with the general resemblance to the knolls of the Middle Drift. The surface of these banks is a slightly undulating flat, rather hollowed in the centre, the level of the surface of each being a little below ordinary high-water mark, the action of the waves playing at the surface of the water preventing the deposition of the sand brought down by the Ribble and other rivers at the top of the banks, sweeping it into the narrow channels between the sandbanks, from which it is carried by tidal currents far out into the open sea, or cast up on the seacoast, and blown by the winds into ranges of sand dunes.

If we assume the sand-knolls of the Middle Drift to have been old sandbanks whose crowns were flattened by the sea, which appears only to take place a little below high-water mark, then as the level of the tops of these knolls rises inland or sinks towards the sea, it would appear that those occupying the lowest ground were formed first, and that as the land sank another series of banks were deposited, whose crowns were denuded by the waves; these, again sinking below the action of the breakers, were succeeded by another and another series of banks, until the maximum elevation, in the neighbourhood of Macclesfield was reached. If these deposits were formed in this way on a gradually subsiding surface, the water would be of nearly the same depth at all the points of deposition during the whole time; and thus, though Blackpool

* "Drift Deposits near Manchester," Trans. Man. Lit. Phil. Soc. vol. ii. (3rd series), p. 457.

and Macclesfield have a difference of elevation of more than 1000 feet, or nearly 200 fathoms, we find the same assemblage of shells of Mollusca.

On the slopes of the knolls, and in the hollows between them, the surface of the Middle-drift sand is found to have been extensively denuded, or eroded: whether this was caused by the action of currents between the banks, or whether, between the Middle-drift and Upper Boulder-clay periods the surface of the former was heaved up into land and subjected to subaerial disintegration followed by subsequent subsidence and the deposition of the latter, is at present doubtful; but the phenomena of erosion are observable over a very large area, including the Manchester district described by Mr. Hull.

Upper Boulder-clay.—This deposit covers the whole country between Ormskirk and Wigan, Wigan and Preston, Preston and Lancaster, as well as the districts of Ulverstone and Blackpool, with a vast sheet of clay, in some instances reaching a thickness of more than 100 feet. In the Preston district, as described above, the various brooks have often cut through this deposit to a great depth, exposing the sands and gravels of the Middle Drift beneath. The hollows in the Middle Drift are always filled up with Upper Boulder-clay, but have been occasionally reexcavated by brooks acting along the lines of the old hollows, producing "drift-valleys" within drift-valleys, double valleys formed entirely in Glacial and Postglacial times. Thus we often find the base of the upper drift, in the brook-cliff, 50 or 60 feet below its base in the adjoining upland plain, less perhaps than 500 yards distant. At Leyland, the top of the Middle Drift descends more than 70 feet in less than half a mile.

The Upper Boulder-clay resembles, in the whole of Lancashire, from Ulverstone to Manchester, the Lower Boulder-clay of the southern part of the *low country* in its physical character, chemical composition, included erratic fragments, and the species of shells of mollusca found with it. Both clays (see Appendix) contain more Silurian erratics in the N.W., and more Carboniferous erratics in the S.E. of Lancashire; both are of a dull Indian-red-coloured tint, caused by the presence of iron derived partly from the Triassic rocks and partly from the Hæmatitic deposits of Furness; in which district the Upper Boulder-clay has a deep, almost lurid, colour. The colour of the Boulder-clay, as has been observed by Mr. Hull*, is perfectly irrespective of the rocks upon which it may lie, being nearly the same when it occurs on the Silurian, Carboniferous, Permian, or Trias.

Here and there, in both the Boulder-clays, faint indications of stratification may be occasionally observed; but the pebbles and boulders are imbedded pell-mell and at all angles in the mass. Large boulders are comparatively rare in both clays, and are generally composed of granite or porphyry, and, more rarely, of lake-district Silurian-grits. Shap-granite pebbles occur in both clays, as far south as Liverpool;

* Geology of the country around Oldham (Mem. Geol. Survey), p. 48.

but the commonest granite in the clay is of a greyish colour, and does not perhaps come from the Lake-district. In the Upper Boulder-clay of Blackpool, Messrs. Binney and Darbishire and myself have found Liassic fossils (one of which Mr. Darbishire, F.G.S., informed me he had also found in the so-called "Bridlington Crag"). Chalk-flints and Permian breccia also occur in the Middle Drift of Red Scar. The base of the "Upper Boulder-clay" is generally a bed of "marl," of tolerably hard consistence; stones are not common in it, but all are much glaciated, being highly polished and intensely scratched; minute fragments of shell are common; and the clay has a deep chocolate-colour. Higher up stones are commoner, less glaciated, and the clay of the usual red colour. At the surface it is often yellow, with whitish seams, extremely stiff, and the surface of the ground extremely wet, and, when not drained, covered with rushes. Much of this land has never been broken by the plough; and its extreme flatness in the district between Preston and Lancaster, has caused the name of the "Fylde" to be given long ago to this tract.

The character of the Upper Boulder-clay in Cheshire is very similar to that in Lancashire. It is of reddish colour, and contains Lake-district and other erratics. South of Hoylake, I observed one chalk-flint, making, with one I found at Blackpool and another at Rufford, three for more than 300 square miles of country, during nearly two years spent continuously in the field. In the grounds of Leasowe Castle there are three large boulders, weighing several tons, which have been extracted from the Boulder-clay in the neighbourhood, which is no doubt the upper clay, as Mr. Morton, F.G.S., in boring through the clay, came to a bed of quicksand resting on a lower clay, which sand no doubt represents the Middle Drift. The Glacial deposits here are covered with a series of Postglacial beds, hereafter described, and rest upon a rock-surface formed of Keuper marls, which have, I believe, been bored into to a considerable depth. The surface of the marls is much below the lowest low-water mark.

Esker Drift.—Here and there, on the western slopes of the Lancashire moorlands, at elevations of from 200 to 400 feet above the mean level of the sea, are found isolated patches or mounds of rubbly gravel, resembling, to some extent, artificial barrows or tumuli; one of them, occurring to the east of Chorley, perhaps from this cause, is called "Pickering Castle." The constituent fragments are far more local than those found in the Middle Drift, which to a slight extent it resembles, and appear to have been mainly derived from the neighbouring escarpments. In some of these gravels a few erratic pebbles, chiefly granites, occur, which may possibly be derived from the denudation of the adjacent Boulder-beds.

From the isolated and detached way in which these mounds of gravel occur, the absence of scratched stones, the rareness of erratic blocks, and the fact that they appear to lie upon the surface of the Upper Boulder-clay, it appears probable that they are identical with the *Kames* of Scotland, which have been described by Mr. A.

Geikie* as more or less solitary mounds of stratified gravel, running in a "sinuous line, from a few yards to several miles in length, averaging perhaps from 50 to 60 feet in height, and rising abruptly from the ground into a narrow crest." Some of the pebbles of the gravel of the Kames described by Mr. Geikie he found to be scratched by ice. Possibly some of the Scotch Kames may be of the Middle-drift age; but, at the same time, even if this be the case, there can be no reason to suppose that ice, on a limited scale, may not have been present during the period of the formation of the Kames, as well as of the Middle-Drift sand and gravel, especially as there can be little doubt that glaciers lingered in the deep valleys of the Cumberland mountains long after the elevation that lifted the Kames high above the sea.

Moraines.—During a few days' leave of absence, spent in the lake-district of Westmoreland and Cumberland, I observed that all the great lakes I visited (Windermere, Grasmere, Thirlmere, Ulleswater, Brothers'water, and Elterwater) lay in true "rock-basins," the rock bottom sloping inwards in all directions, with a gradual inclination at first, and then a sudden deep plunge to the bottom of the lake. The lakes run in chains, like extended river-courses, through deep gorges of rock, the sides of which are scored with glacial markings; these I observed near the head of the lake (with the help of a glass) at the bottom of Windermere itself. *Roches moutonnées* are found at the foot of most of the lakes, notably at Grasmere, where the river has cut for itself a sort of groove, or slot, through the rock. Everywhere the rivers merely carry away the surface- or overflow-water of the lakes, the rock-surface under the water being even steeper on the outlet side than on the inlet, partly perhaps from the deposition of alluvium, but mainly, one cannot help considering, by the rock being worn into a slope by the gradual passing over, onwards and downwards, of the glaciers which must once have filled those gorges, while the enormous pressure from behind, tending to cause an upward movement, would cause the steep and cliff-like declivity of the lower ends of the lake-depressions. At the mouths of nearly all the lateral valleys running into the gorges patches of moraine matter occur, as well as at the entrance of the great Windermere gorge itself, descending as low as to 150 feet above the sea. In the Furness district, immediately to the south, the three drifts of Mr. Hull occur, the Upper Boulder-clay reaching elevations of nearly 300 feet at Hawcoat, near Barrow: and as it occurs at elevations of far greater height in the country to the south of Morecambe Bay, it would appear nearly certain that it, as well as the Middle Drift and Lower Boulder-clay, is absent in the lake-district, having been scooped out by the glaciers which occupied these valleys at the close of the Glacial epoch. I abstain from giving further details of this district, partly because I have published some notes upon it in the 'Geological Magazine,' partly because Mr. Hull has done so, in a paper in the

* "On the Phenomena of the Glacial-drift of Scotland," Trans. Geol. Soc. of Glasgow, vol. i. part ii. 1863, p. 112.

'Edinburgh Philosophical Magazine,' with which I was unfortunately unacquainted when I wrote.

General Observations.—Two beds of Boulder-clay have been shown to occur over the whole of Western Lancashire, divided by a stratum of sand and gravel, often 60 feet thick, but sometimes thinning out so as to cause the two clays to coalesce. The thinning out appears to have been caused, as pointed out by Mr. Hull, by the denudation of the Middle Drift before the deposition of the Upper Boulder-clay, which thus unconformably overlaps the Middle and Lower Drifts. This denudation appears to have been partly marine, and partly possibly subaerial. Mr. Binney, however, still appears to consider the two clays to be one deposit, with an occasionally wedge-shaped mass of sand and gravel intercalated in its midst, absent in places merely because it was not *universally* deposited over the country. Thus, in his admirable description of the Blackpool cliffs of Glacial Drift, he gives the following classification:—

	ft.	ft.
1. Brown clay, mixed with stones	4 to	5
2. Brownish-coloured clay, used for "Till," containing much lime, often *replaced* by stratified beds of *sand* and *gravel*		80
3. Silt, lightish brown, with a few pebbles		2
4. Brownish-coloured Till, with stones to the extent of one-third of the mass exposed		30

In the section accompanying this paper (from Rossall to Blackpool), he represents two masses of sand and gravel disconnected from each other, the northern mass stopping abruptly near the top of the cliff under the Boulder-clay, and the southern mass near the "Royal Edward" (now Bailey's Hotel) also stopping abruptly in the midst of the Boulder-clay occurring all around it. I have now, from time to time, for more than a year, examined this section after heavy storms, and especially when the embankment was in great measure washed away in the spring of last year. I then became convinced that the thin bed of sand under Bailey's Hotel can be continuously traced behind the embankment under the Imperial Hotel until it connects itself with the great mass of sand, with occasional beds of gravel, which, commencing at the little brook called the Gynn, extends to Bispham. Between these two points the Middle Drift is about 60 feet thick, its base being, for the most part, but little above the base of the cliff; but here and there the Lower Boulder-clay rises in the form of a boss or dome. The chief of these occurs near Bispham, where the clay is densely packed with stones, nearly all of which are scratched. The clay forms a low arch, the crown of which is about 22 feet above the base of the cliff; it is separated from the overlying sand by a bed of silt or sandy clay, which is also arched, dipping under the beach at either end, and about 14 inches in thickness. It is the third bed of Mr. Binney's Table and Sections. He has also described an arch of silt covering a boss of Lower Boulder-clay under Bailey's Hotel;

but all traces of this have now disappeared through the wasting of the cliff by the waves, and by the progress of the embankment, undertaken in the hopeless task of stopping their devastations. Beds of sandy silt occur in various horizons in the Middle Drift, as well as occasionally in the Upper Boulder-clay.

Summary and General Conclusions.

From an examination of the facts and inferences brought forward it appears probable:—1. that before the Glacial epoch the N.W. of England was higher above the sea-level than it is at present, and that the sea stood further out, possibly forming a narrow channel between England and Ireland, which were probably more or less connected from Miocene times down to the period immediately preceding the Glacial epoch. Before the commencement of this epoch the land commenced gradually subsiding, the Irish Channel was no longer narrow, and the waves were rapidly denuding across the ends of the various longitudinal hills and valleys, wearing them back and back, until the plains of Wirral and Western Lancashire came into existence, part of the great plain, extending from Liverpool to Lancaster, being since obscured by the deposition of Glacial deposits 200 feet thick. These longitudinal valleys, running in the strike of the Triassic strata, appear to have been formed by the agency of running water, aided by atmospheric causes; and wherever, by natural sequence or subsequent faulting, hard beds rest upon or are thrown against soft, on the eastern sides of these valleys, or on the western sides of the hills, there the dissolving power of western storms of wind and rain have formed long lines of escarpment, running parallel with the strike.

2. That the Mersey occupies at Liverpool a longitudinal valley, or rather a tidal channel excavated at the bottom of one; but its outfall, in Preglacial times, appears from some reason to have been checked or closed, forcing it to turn abruptly westward, flowing over what is now Wallasey-pool gorge, a transvers evalley terminating to the west by escarpments running north and south respectively, which were continuous before the river Mersey cut the transverse gorge in question. The river must have thrown itself over the escarpment, wearing its bed backwards and downwards at the same time. This action probably began to take place before the sea had removed the western side of the valley of which the escarpment lying north of the gorge was the eastern slope.

3. That when the Glacial period commenced, the hilly country became covered with immense glaciers, or possibly an ice-sheet, which, as the cold increased and the land sank, gradually extended over the lower country and reached the sea, by this time covering the lowland plains above referred to, and that the Lower Boulder-clay, with angular local fragments, is due to this land-ice, and may be called terrestrial Lower Boulder-clay.

4. That this portion of the N.W. of England continued subsiding until the land stood 100 feet lower than at present, and that the lowlands of Lancashire and Cheshire were submerged to a depth of

rather less than 20 fathoms. The coast-line, especially near the base of the Cumberland mountains, appears to have been surrounded by an ice-foot, which in winter not only caught up the beach formed in summer and before its formation, scratching the pebbles in every direction as the ice was lifted by the tide, but received on its surface vast quantities of lake-district pebbles, and boulders, brought down from the interior by land-ice, which, at the breaking up of the icefoot, were spread in confused heap-like masses over the Lancashire and Cheshire lowlands, forming the marine Lower Boulder-clay.

5. *Middle Drift.*—That at the close of the period of deposition of the Lower Boulder-clay, the climate ameliorated, the subsidence of the land still continuing, the influx of muddy sediment ceasing, owing to the cessation of glaciers grinding the rocks on the land, and that of sand commencing, owing to the pulverizing of pebbles by the action of breakers on the coast-lines of the Middle-drift sea.

6. That the sand and shingle of the Middle Drift, though found at all elevations from 40 to 100 feet between Blackpool and Preston, to 1200 feet on the Buxton Road near Macclesfield, was everywhere deposited in comparatively shallow water of the same depth, being deposited round the ever-sinking coast-lines, on higher and higher ground, in the form of sand-banks, whose crests mark the level of the *mean high water* of the immediate period of their deposition,—the sinking of the land causing the present elevation of these crests to gradually rise from west to east, or from the sea to the Penine chain, and everywhere (in West Lancashire) to show a marked uniformity of level in a north and south direction. In the Manchester district, owing to the curving round of the high hills of the Penine chain, the Glacial sea extended further east than in West Lancashire, though it does not appear ever to have passed over the ridge dividing it from the Yorkshire area, the eastern edge of which ridge is shown in fig. 1 of Mr. S. V. Wood's paper on the "Boulder-clays of Yorkshire," in the February number of the Quarterly Journal.

7. That if the Middle Drift was thrown down in the form of sand-banks surrounding a gradually subsiding coast, it follows that though the Middle-drift beds at Blackpool, at an elevation of 80 feet, and the Middle Drift at Macclesfield at 1200 feet, must have been formed during one set of conditions, and in the same geological epoch, yet a considerable period of time must have elapsed between the formation of the two deposits; or, in other words, the Macclesfield beds must be newer than those of Blackpool.

8. That the extreme lamination and current-bedding in the Middle Drift would, without the littoral character of the shells found in it, point to shallow-water conditions; but this current-bedding is often so intense as to preclude the idea of its being entirely due to ordinary tidal streams, and to suggest rather the sudden currents which would be caused by the occasional melting of ice altering the temperature of the water. That ice was occasionally present in the Middle-drift sea is proved by the fact that beds with scratched pebbles are occasionally found in it, both in the Blackpool, Preston, and Chorley districts; and the contorted and folded Middle Drift

seen on the northern side of Morecambe Bay is no doubt due to the stranding of ice-bergs.

9. That the surface of the Middle Drift in Lancashire appears to have been everywhere eroded into small hollows and undulations, apparently caused by subaerial denudation; if this be so (and there are many reasons to believe it was), the country must have risen above the Middle-drift sea, become land, have suffered denudation, and again sunk beneath the sea before the deposition of the Upper Boulder-clay. Be that as it may, there can be no doubt that the Upper Till invariably rests on an eroded surface of Middle Drift, the two formations being unconformable.

10. That at the close of the period during which the Middle Drift became eroded, the climate again became cold, and that portion of land which stood above the sea more or less covered with ice; this tract was probably considerable, as the land during the deepest submergence of the Upper-till period does not appear to have been more thon 800 feet lower than at present, the clays in the deeper valleys of the Penine chain, at greater elevations, probably belonging to the high-level Lower Boulder-clay. With the change of climate came an alteration in the character of the deposits; sands and gravels were no longer thrown down, owing probably to the coasts being again surrounded by an ice-foot; and the grinding of glaciers over the land caused vast quantities of clay to be carried out to sea, held in suspension by the water, and spread over the country, where stratification is now but faintly visible, probably from the extreme fineness of the grains of matter of which the Upper Till is composed: the included stones in it, though erratic, are always more or less rounded; and at whatever height, so far as I have seen it, this formation occurs, it invariably contains more or less perfect shells of marine mollusca. None of these are of an extremely arctic character, *Turritella communis*, *Buccinum undatum*, *Purpura lapillus*, *Cardium edule*, and *Tellina balthica* being the commonest. All these occur in the Middle Drift, as well as many others. The first also occurs in the marine Lower Boulder-clay, and also in the Upper Till.

11. That before the surface of the Upper Boulder-clay became land, and probably before any upward movement commenced, the climate appears to have ameliorated, the ice-foot to have disappeared, the formation of shingle to have recommenced, and the glaciers to have sufficiently retreated to no longer send down vast quantities of clay to the sea, the dust, so to speak, of their gigantic sawing of the valleys of the country; for on the surface of the Upper Till, in the north of Lancashire, often at elevations of 500 or 600 feet, occur mounds of water-worn gravels, similar to those known as Kames in Scotland, and Eskers in Ireland.

12. That the glaciers appear to have lingered especially in the deep valleys of the Cumberland and Westmoreland lake district, where, in many cases (Borrodale, Langdale, Liza valley), they have excavated out the marine drift, and shed their moraines in the space thus left vacant. In the latter valley I found the moraine-mounds to be peculiarly numerous and well preserved.

Appendix.

Percentage of the Rocks included in the Glacial drifts of Lancashire and N.W. Cheshire.

MANCHESTER (mean of three examinations, given by Mr. Binney, Trans. Man. Lit. Phil. Soc. vol. x. p. 133).

	Angular.	Partly rounded.		Total.
Granites, greenstones, and other igneous rocks	5·0	10·0	6·0	21
Slates and Silurians	3·66	9·0	8·33	21
Mountain Limestones	1·0	3·0	2·0	6
Coal-measures	25·33	19·0	5·0	49·33
New Red sandstones	2·0	0·66	0·0	2·66
Striated rocks	...	...	...	1·66

GORTON, near Manchester (determined by Prof. Ramsay. Mem. Geol. Survey, 'Geology of the country around Oldham').

Granite	6	43 per cent. igneous.
Felspar porphyry	31	
Felstone	2	
Porphyritic conglomerate	4	
Ironstone	2	
Silurian grits		37 per cent.
Carboniferous limestone	3	17 per cent. Carboniferous.
Carboniferous grits	14	

EASTHAM, on the MERSEY, near BIRKENHEAD (given by Mr. Hull, Mem. on Oldham, p. 51).

Granite	8	37 per cent. igneous.
Greenstone	8	
Felspar porphyry	5	
Felstone	7	
Quartz rock	9	
Ironstone	1	
Silurian grits		43 per cent.
Carboniferous limestone	4	5 per cent. carboniferous.
Carboniferous grits	1	
Triassic or Permian sandstone	12	

---

7. *On the* POSTGLACIAL DEPOSITS *of* WESTERN LANCASHIRE *and* CHESHIRE*. By C. E. DE RANCE, Esq., F.G.S., of the Geological Survey of England and Wales.

Wirral, Cheshire.—The general form of the ground of the peninsula of Wirral has already been described in my paper on the glacial phenomena of the district,—the northern portion being a low alluvial plain, with a hill in the centre (on which Liscard is built), rising like an island above it, and bounded on the south by a line of old cliff, abruptly terminating the various longitudinal valleys which, running with the strike of the rocks, traverse the southern portion of the district. Much of this low plain is below the sea-level, being naturally protected from the sea by a range of sand-hills, about

* Communicated with the permission of the Director-General.

50 feet high: these, however, in the neighbourhood of Leasowe, were washed away by the continual encroachment of the sea many years ago, and their place artificially supplied by an embankment, which has to be continually repaired, and, after heavy storms, even partially rebuilt, the cost of which is paid by an acreage-toll levied on the landowners of the district.

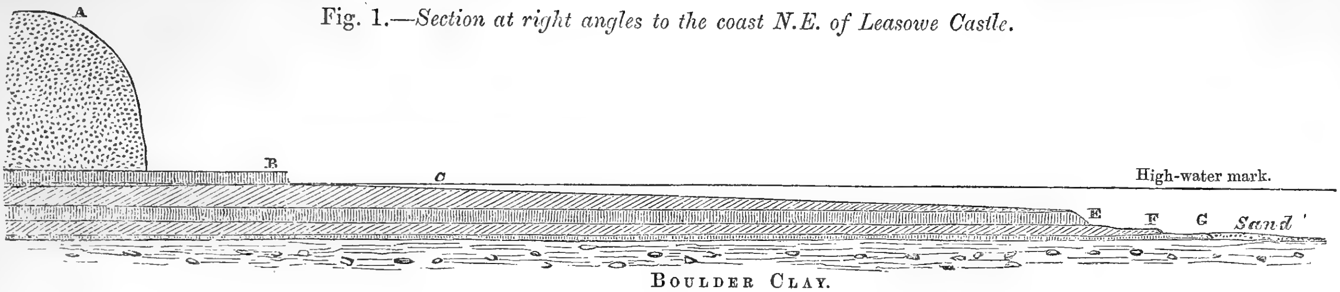
The drainage of the district is naturally much obstructed. Deep sluices, like small canals, often from 16 to 20 feet deep, carry the water into the river Birket, which falls into Wallasey Pool, an arm, or tributary, of the Mersey. In the sections exposed in the Birket and sluices, beds of peat, often as much as 16 feet in thickness, are seen resting on grey clays; and on the northern portion of the tract a bed of sandy marine silt occurs on the peat, caused by recent inroads of the sea. The sand dunes, when their bases are seen, are found almost invariably to rest upon a surface of peat. At New Brighton, on the Mersey, there is a slight exception, the sand resting on the bare rock, belonging to the Bunter Pebble-beds. A little further west, the red beds of the Upper Mottled Sandstone occur, jutting out into the sea, forming the picturesque cliffs known as the "Red Noses."

Walking along the sea-coast from the Red Noses towards Hoylake, a little before reaching Leasowe Castle, the section given in fig. 1 is reached. The sand-dunes (A) are about 35 feet in height, rest on a flat-surface peat (B) about 2 feet thick, which runs out seawards about five yards, forming a terrace, resting on a bed of pale, pure, grey-coloured clay (C), containing *Cardium edule*, and with a marshy growth at its surface. This clay rests upon a thin bed of peat (E) resting upon another bed of grey clay, covering still another seam of peat, which is believed to rest on the Boulder-clay, here covered up with sea-sand.

In fig. 2 a greater thickness of peat is observed, and it is split in two by a bed of olive-green-coloured sand (B′), containing *Tellina balthica* and *Cardium edule*. A sand of probably the same age occurs in Lancashire, north of Southport, and I shall hereafter, for convenience, call it the "*Tellina-balthica* sand."

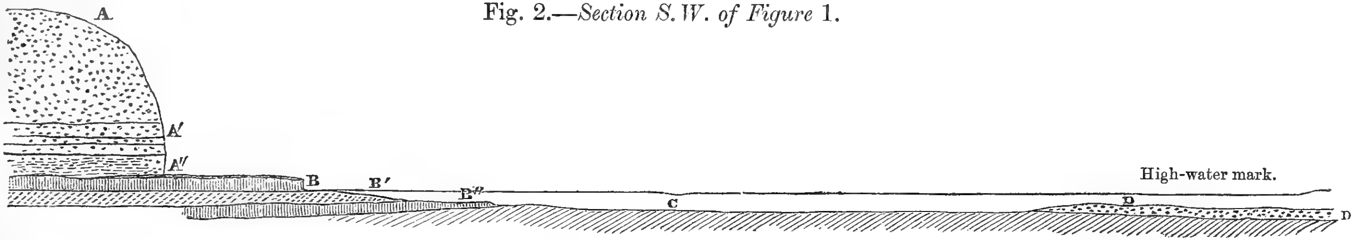
The peat below the sand (B″) is about 2 feet in thickness, and rests upon the usual grey clay (C) with a marshy growth at the top. Its base is concealed by sand, and it is doubtful whether it is marine or fluviatile at this point, as these conditions vary in a few yards. There can be little doubt that the whole of the silts of the Birket plain were deposited when this tract was an estuary of the Mersey, that river having, even in historical times, flowed through the gorge, at the bottom of which now runs Wallasey Pool into the sea, between Leasowe and New Brighton, until, through the outlet being choked by the deposition of alluvium, the drainage has to a certain extent been reversed. Whilst this deposition went on, freshwater forms might have lived in pools of fresh water in hollows of the Boulder-clay, simultaneously with marine forms in other pools filled by high tides a few feet distant,—fluviatile and marine forms of life preponderating horizontally and vertically in the silts, according to whether freshets

Fig. 1.—*Section at right angles to the coast N.E. of Leasowe Castle.*



A. Sand dunes, 35 feet. B. Peat, 2 feet. C. Marine clay, 3 to 5 feet.
E. Peat. F. Grey clay with marshy roots, 1 to 2 feet. G. Peat, 1 foot.

Fig. 2.—*Section S.W. of Figure 1.*



A. Blown sand with marine shells. A′. Blown sand with seams of peat. A″. *Bithinia-tentaculata* sand.
B. Peat. B′. *Tellina-balthica* sand. B″. Peat (Main peat). C. Marsh clay with plant growth on upper surface. D. Sea sand.

or spring tides happened to be in the ascendant. This state of things is going on at the present time in the marshes of the Ribble, between Preston and Southport, where, after heavy rains or floods, freshwater shells may be found, during neap tides, in the hollows in the *Scrobicularia*-mud, and where, after spring tides, crabs may be found living in all the ditches for one or two miles inland.

In Section 2, and, in fact, in all other sections where the junction of the sand dunes with the underlying peat is visible, the base of the blown sand is found to be stratified (A″), and to contain freshwater shells, especially *Bithinia tentaculata*. It would therefore appear that when the sand commenced to be blown, both in Cheshire and in Lancashire, the surface of the country was a freshwater morass or bog, which was gradually filled up by the sand; indeed, in Cheshire and at Southshore, near Blackpool (but not, so far as I am aware, between Liverpool and Southport, or at Lytham), seams of peat, from the tenth of an inch to 3 inches in thickness, occur in the first four or five feet of the sand dunes (A″), sometimes as many as ten or eleven seams occurring in a foot, always in strictly horizontal layers. This stratified sand I have called, for convenience, the "*Bithinia-tentaculata* sand."

West of Section 2, and about 50 yards east of Leasowe Embankment, the *Tellina*-sand has thinned out, but reappears on the other side of the sea-wall—the two beds of peat, again coalesced, reaching a thickness of five feet; beneath, a thick bed of grey clay occurs, full of valves of *Scrobicularia piperata*. This I have called the "Lower *Scrobicularia*-clay," as a bed with *Scrobicularia* lies *above* the thick peat of Lancashire. In this section the first six feet of the sand dunes is the "*Bithinia*-sand," with seams of peat, at every 10 or 12 inches. Above the last seam of peat the sand contains worn marine shells, blown in and associated with freshwater and land-shells, which lived and died on the spot.

Still further west, at a point about ten yards north-east of the north-east end of the embankment, the peat is about 5 feet thick, resting on 9 feet of *Scrobicularia*-clay, the latter resting on the Upper Boulder-clay, which is of a deep purplish red, with blue seams, and, under the action of the waves, has been furrowed into long grooves, running at right angles, or slightly obliquely to the shore. It is honeycombed by marine organisms, and here and there bored by *Pholades*. All the pebbles are erratic; and occasional large boulders are seen overgrown with tangle. The surface of the grey *Scrobicularia*-clay is, as before, a marshy growth; but it is penetrated by the large and massive roots of a perfect forest of trees, found at the base of the peat above.

Further west, in the centre of the embankment, these various beds thin very much, the Boulder-clay rising higher, in a kind of boss or dome; and it is therefore probable that the beds above described lie in a hollow cut in the Boulder-clay by the Mersey when this tract was its estuary.

Behind the embankment a thin bed of blown sand is found resting on peat, near the Leasowe Lighthouse. About 6 feet of this is visible

in a pond, and it appears to rest directly on the Boulder-clay, in the sluice bank. A little south, at the foot of the embankment, on the shore, a thin seam of peat, resting on about 16 inches of grey clay, is seen lying on the Boulder-clay. The surface of the peat, between high- and low-water mark, is planted, so to speak, at every 20 yards, with a double row of young saplings, apparently hazels, about 3 feet apart, running in parallels diagonally to the shore in a north-west and south-east direction. Their roots are in the grey clay; but there is some reason to believe that they were planted at a comparatively late date, as I was able to trace the "grey clay" in question to an horizon above that of the thick peat, which has so great a development on either side of the sea-bank.

From the end of the bank to the river Dee, at Hoylake, the coast is bordered by sand hills, occupying a tract about half a mile in breadth, and through which the Hoylake and Birkenhead Railway is built. Beneath the sand dunes at Dove Marks (fig. 3), east of Hoylake, the following succession of beds occurs:—

	feet.
1. *Bithinia-tentaculata* sand	2–4
2. Peat. This bed occasionally appears to have formed a cultivated surface before the deposition of the sand	1
3. *Tellina-balthica* sand, with seams of bluish clay. This is apparently the seam in which Mr. Ecroyd Smith has recorded the presence of Saxon and Roman coins	2
4. Peat. The representative of the thick peat of Lancashire and Cheshire	3
5. Bluish-grey clay, the upper portion of freshwater origin	3
" " the lower of marine, and containing *Scrobiculariæ*	1
6. Peat, with a few stumps of trees with their roots in	$1\frac{1}{2}$
7. Boulder-clay. From half-tide to the lowest water-mark.	

In the lowest peat (6) no historical or natural remains have, I believe, ever been found; but some of the flint weapons in the Liverpool Museum are believed to have come out of this seam, others from the base of the peat above. In addition to the flint weapons, Mr. Ecroyd Smith * believes it to contain bones of *Bos primigenius* and *Megaceros hibernicus*, and of Cetacea; but these bones, I think, possibly are those that were found in the blue silt resting on a peat-bed with a forest on its surface, in excavating Wallasey Pool for docks in 1858, and which have been described by Mr. T. J. Moore in the 'Lancashire Historic Society's Transactions.' In this case they are more probably of the age of the *Tellina-balthica* sand, as the peat in Wallasey Pool no doubt belongs to the main or thick peat of the district, which, near the Birket, attains a thickness of nearly 20 feet. In this peat bones of horses, oxen, and deer have been found, as well as great numbers of Roman and Saxon coins, and in one portion arrowheads of stone, shell, and flint. The latter substance must have been brought to the spot, either from southern counties or from eastern Yorkshire. Great numbers of coins of all ages are constantly being

* 'Reliquary,' April 1865; also, Rev. A. Hume, LL.D., in 'Ancient Meols;' Morton's 'Geology of Liverpool,' p. 49; 'Proc. of Hist. Soc. of Lancashire and Cheshire' for various years.

picked up on the North-Cheshire beach, most of which are no doubt washed out of the main peat and the overlying *Bithinia* and *Tellina* sands. Amongst those preserved in the Liverpool Museum are some of Nero, Antoninus Pius (A.D. 138–160), Marcus Aurelius, others struck at Carthage, others struck by Canute and by various English kings from William I. to William III. Various antiquities have been described by Dr. Hume from this coast in his 'Ancient Meols;' but the exact position from which they were derived is in almost every case extremely doubtful. But after carefully examining all the objects from the coast of Wirral in the Liverpool Museum, as well as the coast-section, the following correlation of historical periods with the geological formations appears to be warranted:—

Recent to Norman Conquest	*Sand dunes.*
Danes and Saxons	B.-tentaculata *sand.*
Saxons	*Peat and made earth.*
Saxons and Romans	Tell.-balthica *sand.*
Romans and Celts	*Main peat.*
Celts	,, *lower portion.*
Palæolithic-weapons race	*Lower blue silt.*
No trace of man	*Lowest peat.*

Liverpool and the Country between the Rivers Alt and Douglas.—The form of the ground of this tract has already been mentioned as a great plain covered with peat-moss (fig. 3), mostly below high-water mark, with the exception of the few miles between Liverpool and Bootle, where some hard beds of the Trias, thrown up by faults, form one or two lines of escarpment, more or less covered with Boulder-drift. The peat and other postglacial deposits fringed this comparatively high ground, and connected the low grounds of the Alt plain with those of Wirral described above. The reexcavation of the valleys after the glacial period appears to have been nearly complete before the period when the peat and its underlying blue clays were formed and deposited; for we find these deposits, not only at the bottom of the rivers Dee and Mersey and the old tributary of the latter, Wallasey Pool, but in the bottoms of all the little narrow brook-valleys on either side of the Ribble, as well as under the alluvium at the bottom of the great drift-cut gorge of that fine river. The deposition of freshwater silt, and the subsequent growth of peat, over so large a tract, embracing the whole of the north-west of England, must necessarily have been produced by some great cause tending to obstruct the natural drainage, causing the accumulation of vast freshwater lakes, afterwards land covered with dense forests, destined again to become swampy marshes, eventually choked with the growth of peat-moss.

An examination of the postglacial deposits between the rivers Mersey and Ribble tends in some measure to throw light upon the conditions which may have produced this obstruction of drainage. This peat-moss plain (shaded in fig. 3) is bounded to the east by a tract of country with an average elevation of 125 feet, separated from the lower plain by what may be called a double cliff, the first, of preglacial age (formed in the hard Keuper Sandstone rocks), being concealed

by Boulder-clay, which once had a great thickness over the lowland plain, as it has still over the equally low *rock-surface* in the Preston

Fig. 3.—*Sketch-map of part of Western Lancashire and Cheshire.*

district, but has since been swept away by marine denudation (as in

the case of the Birket plain in Wirral), leaving a second cliff formed of Boulder-clay, in some places several hundred yards in front of that of preglacial age. The Boulder-clay cliff itself, however, is seldom visible, being concealed in the district between the rivers Alt and Douglas by a range of old sand dunes, formed along the postglacial sea-margin, as the land began to rise, after the formation of the clay-cliffs referred to. This sand is at once distinguishable from the sand of the modern sand dunes by its large grain, and by the absence of black specks of some hard substance invariably found in the latter. I have called it the "Shirdley-Hill sand," and have described it at length in the Geological-Survey description of the quarter sheet between Liverpool and Southport. These old sand dunes form a line of more or less detached hillocks (fig. 3), the chief of which are known as Pye Hills and Shirdley Hill, as well as hills in Haskayne, near Hightown, and several places in Halsall. In the latter parish, near the village, the sand forms the floor of the peat, which varies from 10 to 2 feet in thickness, resting on about 10 feet of sand, which contains many small pebbles, and occasionally a few marine shells. Its surface is here about 4 feet lower than the base of the old sand dunes, and must therefore be the actual strand of the postglacial sea when it covered what is now the peat-moss plain. The sand can be traced northwards as far as a hill, or bank of Boulder-clay, about 50 feet high, occurring on the south bank of the river Douglas, near Tarleton. It can also be traced eastwards, along the low lines of this river, in the direction of Wigan, everywhere underlying the main or thick peat when existing as a marine deposit. A bed of sand occurs in the surface of the upper, or 125-feet, plain, in the neighbourhood of Aintree, Maghull, Orrell, and Ormskirk, which is apparently of the same age as the Shirdley-Hill sand, having every appearance of having been blown from the line of old sand dunes referred to above. It is an extremely variable deposit, occurring at the top of a hill and not at the bottom, or *vice versâ*, on the one side of a valley and not on the other, and often thinning from 16 feet to 2 feet in less than a quarter of a mile. On the upland plain it contains minute fragments of marine shells, apparently *Cardium edule* and *Turritella terebra*, and in one instance a perfect freshwater *Limnæa*; and it invariably rests upon a bed of peat, varying from 4 feet to an inch in thickness. It would therefore appear probable that, after the elevation that heaved the surface of the Upper Boulder-clay into land, the sea-margin stood much further out in the Irish Channel. The gradual wearing back of the Boulder-clay cliffs, probably during a fresh subsidence, produced the low plains between the Dee and Mersey and Alt and Douglas, on the surface of which the Shirdley sand was deposited, which, in the latter plain, on fresh elevation, was blown into sand dunes, and from them far into the inland country. In the former plain the denudation was so complete, that the Boulder-clay cliff was worn back and back until all vestiges were destroyed; and the edges of the postglacial deposits rest against the base of the old preglacial cliff, which extends from the one river to the other. No sandy beds appear to be here present; but they were

probably swept away by after-denudation. Neither does any representative of the "Shirdley-Hill sand" occur in the Ribble estuary or valley, possibly because the latter was not so deep or fully formed during that period as now. But much further north, on the north shore of Morecambe Bay, at the top of a low cliff of Upper Boulder-clay, at Rampside near Barrow, is a well-known postglacial deposit, containing species of marine shells, which have been enumerated by Miss Hodgson, of Ulverstone. This deposit appeared to me in some measure to resemble a raised beach, or rather sea-bed, occurring on the southern shore of the bay, west of Pilling, between Fleetwood and Lancaster, which I found to underlie the main or thick peat of that area, and to abut against a high cliff of Upper Boulder-clay on the top of which the village of Preesall is built. The sand and shingle contain *Cardium edule*, *Natica*, and other marine shells, and fragments of hæmititic iron-ore from the Furness district. The deposit is but rarely seen; but there can be little doubt that the whole of the immense peat-moss plain forming the country on the southern side of Morecambe Bay, between the sea and the glacial-drift covered Fylde, was once the postglacial sea-bottom, and that Morecambe Bay was shaved across by the sea at the same period as the plains between the Dee and Mersey and the Alt and Douglas—the only difference being that, with the exception of the peat-moss plain between Pilling and Fleetwood, the whole of the Morecambe plain is again beneath the waves, while all the skill of the engineer has to be exerted to prevent the Alt and Douglas portion sinking below them.

When the bottom of the bay is examined, it is found to consist of red-sandstone rock, covered with a thin bed of red Boulder-clay; this, again, is covered with a freshwater blue clay, on which grew a forest, which is covered with peat. It is clear, then, that after the postglacial sea had formed a plain in the glacial deposits, leaving cliffs all round of Boulder-clay, the whole bay became land, drainage was obstructed, and freshwater-beds were thrown down. These afterwards became terrestrial surfaces, supporting a forest, afterwards destroyed by the growth of peat,—a result exactly similar to that obtained from an examination of the estuary of the Mersey, mentioned above.

The light-coloured blue clay, occurring under the main thick peat, I have called the "Lower *Cyclas*-clay," as, in the neighbourhood of Southport and Formby, where it is well developed, being about 20 feet thick, it contains the shell *Cyclas cornea*, occasionally to the almost total exclusion of any other form. The clay does not extend eastwards under the whole of the moss, but gradually thins out along a line nearly parallel with the coast, at a distance of from three to four miles from it. To the east of this line the peat is about 12 feet thick, resting on the Shirdley-Hill sand. It is drier and more friable than where resting on the "*Cyclas*-clay," and is made chiefly of layers of more or less decomposed heather-stems and leaves, instead of *Sphagnum* and other mosses, as is the case with the peat on the clay. At the base of the peat, in both instances, a submerged forest is found. Near Halsall the trees are chiefly oak, some of them of very large

size. In most instances the roots of the trees are found extending far down into the subsoil beneath; and when the overlying peat is removed, about 2 feet of the stem is found left standing above the surface of the ground in which it grew. Submarine forests are found, more or less, all along the Lancashire coast, as in North Cheshire—and when not seen, are present beneath the sea-sand, occurring sometimes at Southport 80 feet below high-water mark. The submarine peat and forest is everywhere connected with the peat and submerged forest of the lowlands (or "broads," as they would be called in some districts), running under the sand dunes which fringe the coast, in a belt varying from a half to nearly four miles in breadth, and often reaching an elevation of nearly 100 feet above the level of the sea.

To the north-east of Southport, towards the river Douglass, the site of the old lake, Martin-Mere, called by Camden "the biggest mere in Lancashire," is covered with very thick and dense peat, resting on the *Cyclas*-clay. Its waters appear to have been bounded to the north by the hill of Boulder-clay, masked at the bottom by Shirdley-Hill sand, near Tarleton, referred to in the description of that sand, the position of which is traced on fig. 3.

The lake contained in the sixteenth century 3400 acres, but was drained in 1692 by Mr. Thomas Fleetwood, who spent an enormous sum of money in doing so. While the excavations were going on, eight canoes, each hewn out of a single tree, were found; one of them, I believe, is in the British Museum. According to Leigh's 'Natural History of Lancashire,' published in 1700, one of the canoes had iron plates on it. He also relates the finding of great quantities of fir stocks and fir-apples. The fir trees found under the moss, then as now, were so bituminous as to be used as candles by the neighbouring inhabitants. Leigh also mentions that, under the moss, distinct plantations of birch, oak, ash, and pine were found, that had evidently been planted. Some trees that I have observed dug up from the moss over the site of this lake certainly appear to have been cut down by some blunt implement, possibly a stone axe; and many of the oak trees in the submarine forest near the mouth of the Alt appear to be placed in right lines at equal distances. But the bases of these have every appearance of having become gradually rotten, owing to the obstruction of drainage causing the rise of water, in which peat began to form, and into which the trunks were afterwards blown by powerful westerly and south-westerly winds, to which the half-rotted stems formed an easy prey. Everywhere in West Lancashire the heads of the buried trees generally lie to the north-east, especially when the trunk is not entirely separated from the roots.

The trees dug up from the mosses are generally of a black colour; and the wood has often acquired a considerable density, and is occasionally used for furniture and house-fittings. The trees at the base of the peat at Rimrose Brook, the mouth of the Alt, Formby, and near Southport are chiefly oaks and pollard ashes, in Croston and Marton Mosses chiefly oaks and yews, and in Lytham Moss oaks and

alders. When the Scotch fir occurs it is generally with the oak, with the exception of the submarine forest near Rossall, where there appears to be a distinct horizon of Scotch fir at the base of the peat, under another tree-surface consisting of oaks. In this, as in all the other sections in Lancashire and Cheshire, a seam of hazel occurs near the top of the peat. The wood of this is invariably of a peculiar red colour, and is called by the peat-cutters "red wood."

It is thus clear that the whole of the lowlands of Lancashire and Cheshire, as well as the slopes of the Triassic hills, were covered, before the growth of the peat, with forests, including oaks of the largest size, pollard ashes, beeches, alders, yews, firs—that after this the growth of peat ensued, varied by occasional seams of brushwood, of which shrubs of the genera holly, hazel, and spurge played the most important part; and on the surface of the peat, at the present day, the spurges and the willows, in the drier portions, are gradually adding their tale of leaves. The peat was probably formed during very gradual subsidence, the seams of brushwood indicating pauses.

Upper Scrobicularia-clay.—Resting on the surface of the peat, on both sides of the river Wyre between Fleetwood and Blackpool, and at the mouth of the river Alt, near Hightown, is a deposit of tidal alluvium, reaching a thickness of nearly 30 feet south of Fleetwood. At a depth of about 8 feet, twenty years ago, a great number of Roman coins were found in this deposit in the latter district. The surface of the spot where the coins were found is about 2 feet above high-water mark; and the "*Scrobicularia*-clay" is covered with from 3 to 4 feet of blown sand. The surface of the clay is therefore rather below the sea-level. As the deposit contains the estuarine shell *Scrobicularia piperata* at all depths, including that of 8 feet, as proved in borings, it follows that, when the coins were lost by the Romans, the land could not have been higher than at present, as has been proved by Mr. Geikie to have been the case in Scotland.

By the side of a brook which runs up from Freckleton Point, in the estuary of the Mersey, near the town of Kirkham, is the site of a Roman bath, near which a splendid Roman bronze shield was found, now in the British Museum; as this bath is only about 7 feet above high-water mark, it would tend to prove that the country is not lower now than it was in Roman times; and there is therefore little doubt that the level of the country has not materially changed, and that the Romans lost their money scrambling and slipping over the soft salt-marsh mud.

Blown Sand.—The blown sand of Lancashire, south of the Ribble, resembles that of Cheshire. It is composed of very fine grains, and contains black specks, probably of hornblende. The dunes between Liverpool and Southport rise to a height of 70 or 80 feet above the level of the sea, and between Lytham and Blackpool to a height of from 60 to 70 feet; but they seldom rise above 40 feet near Fleetwood. Where the base of the sand-hills is seen resting on the peat, as at Southshore, it is found to consist of the "*Bythinia*-sand," as in Cheshire. In the sand dunes north of the Ribble, especially near

Fleetwood, the grains of sand are much larger, probably owing to the proximity of shingle beaches derived from the Boulder-clay, which, by the action of the waves, becomes sand.

Denudation of the Gorge of the Ribble.—The Ribble has been mentioned as having cut through the great-drift plain, between Chorley and Lancaster, down to the rock beneath. It has, in fact, excavated its bed, near Preston, to the lowest possible level, namely to low-water mark, the spring tides flowing two or three miles up the river beyond the town. The river has excavated for itself a gorge, with an average width of a mile and a half, bounded by steep walls, or bluffs, here and there worn into cliffs, exhibiting fine sections of the glacial drifts, of an average elevation of from 80 to 200 feet.

The whole of the excavation of this gorge, 20 miles long and 150 feet deep, must therefore have taken place since the era of the Upper Boulder-clay, or in postglacial times, and since the country had acquired its present level; for if the country had stood lower, the sea would have shaved the country across, instead of excavating a comparatively narrow valley; and if the country had stood higher, the river would have excavated its bed deeper, or below low-water mark, which is not the case, as, whenever the rock is visible, it is seen extending under the drift as a flat surface, in every direction.

The Ribble wanders in a series of S-like curves through an alluvial plain; and wherever the bend of the S cuts the boundary-walls of the plain, there the process of river-cliff-making ensues: the cliff is worn back and back, until the river, by cutting across a bend, finds a new channel; then the talus formed at the base of the cliff, being no longer removed by the river, accumulates, until a gradual slope, covered with grass, is formed, and the cliff becomes a bluff.

As the bends of the river are nearly a mile apart, and they alone exercise the primary horizontal denuding power, it will be seen that, for the formation of the bluffs, once cliffs, the bends of the river must have been successively upon every point of the bluffs forming the bounds of the plain. And as the vertices of these bends move with extreme slowness, it follows that, when the river twice denudes the same point, it must flow at a *lower* level the second time than it did the first.

This will account for the fact that terraces of Lower Boulder-clay have been left at the base of the bluffs, at higher levels than the alluvial plain—the top of the terrace marking the level of the river when it last denuded that point.

The river is now depositing silt, or alluvium, during every flood produced by a freshet from the land or a high tide from the sea, except at the points where the denudation of the old banks is at work. Similarly we find, here and there, superimposed terraces of alluvial gravel, at heights of from 20 to 100 feet above the present level, formed in the concave curves of the S's, when it stood higher than at present, and cut the terraces in the Lower Boulder-clay before referred to. The Ribble, in other parts of its course, flows across

the alluvial plain, bounded by secondary banks, from 10 to 25 feet in height, depositing alluvium on the one bank and horizontally denuding the other. This secondary denuding, though important from being exercised along the whole course of the river, is of much less importance than that exercised at the elbows of the curves of the stream.

I have gone thus at length into the origin of these cliffs, owing to Mr. Mackintosh having described them as having been formed by the sea, and having, through misapprehension, represented me as holding that opinion.

General Conclusions.

1. After the deposition of the Esker drift, the country appears to have gradually risen, probably to an elevation of from 200 to 300 feet higher than at present; but before this elevation was reached, a pause appears to have taken place, during which great denudation took place—the sea having eroded the cliffs of glacial drift in Western Lancashire and Cheshire, back and back, until the great low-lying plains, now covered with peat-moss, came into existence.

2. At the present time, nearly two-thirds of the Irish Sea is within the 30-fathom line, which runs on the east side, nearly in a straight line from the Mull of Galloway to St. David's Head, passing to the west of the Isle of Man. The whole of this tract would therefore become land if there were an elevation of 200 feet. Between this line and the coast of Ireland is a deep channel, generally about a mile broad, of an average depth of from 60 to 70 fathoms; the deepest portions, or rather points, are off Magee Island, 84 fathoms (504 feet), and off Larne, 112 fathoms (672 feet): near this point is the Highland Rock, in the shallow called "the Maidens," in only 6 fathoms, being a fall of 648 feet in half a mile. Off the coast of Galloway is a narrow channel, about 24 miles long; its deepest point is 149 fathoms, or 894 feet, opposite Belfast Lough. The deepest water in a straight line between Lancaster and Dundalk is 57 fathoms (342 feet); between Dublin and Holyhead, 93 fathoms. This latter channel shallows to the south, towards the "line of least depth" between England and Wales and Ireland, which runs in a curve pointing south, from the peninsula of Caernarvon to Arklow, in Ireland, marking probably the watershed from which the rivers, which probably formed the long narrow channels occurring in the otherwise flat surface of the Irish Sea-bed, described above. Southward of this line, the deepest portion of which is only 44 fathoms deep (264 feet), the channels again deepen, increasing in depth towards the open sea, the average being about 60 fathoms.

3. If in postglacial times the land rose as much as 280 feet above its present level, the coast-line ran from the Mull of Galloway to St. David's Head, and Ireland was connected with Wales by a narrow isthmus over this "line of least depth," over which the postglacial mammals, the Germanic flora, and man himself may have migrated. This connexion would appear to have taken place

after the formation of the lowland plains, and during a period when all the hollows in the much-denuded glacial deposits, both in Lancashire and in the Isle of Man, were occupied by lakes, which threw down the grey silt which I have called the "Lower *Cyclas*-clay," and in which the *Cervus megaceros* is so often found entombed.

4. It appears probable that glaciers still lingered in the deep valley of the Lake-district during the whole of the period occupied by the rising of the land, the pause, and its subsequent denudation and the connexion of England with the Isle of Man and Wales with Ireland. The climate would probably be rather colder than during the Esker-drift period, owing to the greater extent of land cooling the air; but the temperature, apart from local causes, was no doubt becoming warmer.

5. At the close of the pause in elevation, before the lake-period, when the sea still occupied the low plains of Western Lancashire, the Shirdley-Hill sand and the Preesall shingle banks came into existence, forming a line of old sand dunes, from which sand was blown over the face of the country around Ormskirk, covering up the "lower peat" formed during the period of the pause. Below these old sand dunes in the plain, flats of this sand are occasionally found, forming the actual sea-bottom of the Shirdley-Hill-sand sea. The surface of the sand is worn, more or less, into channels by brooks, or small rivers, which no doubt flowed into the lakes, which, gradually increasing in size, afterwards covered the whole of these low-lying plains, not only between Liverpool and Southport, but between Fleetwood and Lancaster, and all the broad estuaries of the rivers flowing down from the Cumberland mountains, on the north side of Morecambe Bay, with the freshwater "lower *Cyclas*-clay."

6. During the formation of the *Cyclas*-clay, the entrance, or outlet, of all the river- and brook-valleys appears to have been choked and obstructed; for freshwater lacustrine marls almost invariably form the base of the alluvium of the valleys in Lancashire and Cheshire. On the surface of the clay, on the plains and in the valleys, a forest of Scotch firs and oaks came into existence, the former sometimes appearing first, and being succeeded by the latter. The trees attained an immense size, owing probably to the continental conditions prevailing.

7. The country began to subside; drainage became still more obstructed; the growth of peat ensued; the sea encroached upon the land, and gradually worked its way eastwards over the sea-bottom of postglacial times—a movement yet in progress, the lowland of Western Lancashire and Cheshire being preserved from it only by artificial means. In a few places the ground has, partly naturally, partly artificially, been reclaimed from the sea, as at the mouth of the Alt and Wyre, where it has deposited an Upper *Scrobicularia*-clay on the peat.

8. Here and there, also, sand has begun to blow during the last three or four hundred years, the lines of sand dunes helping to keep the sea out. Everywhere the sand, when it first began to form, was blown into fresh water.

8. Observations *on* Modern Glacial Action *in* Canada. By the Rev. W. Bleasdell, M.A.

(Communicated by Principal Dawson, F.R.S., F.G.S.)

Sir Charles Lyell, in his 'Principles of Geology,' has drawn attention to the effects of glacial action in Canada in the transportation of large stones and boulders on the shores of the river St. Lawrence to new positions by the powerful agency there exercised, more or less, every winter. As this subject possesses much geological importance, I write down a few observations of this kind that may be of interest.

There can be no doubt that in every portion of the province where large rivers, streams, and lakes abound, the effects of ice may be seen in the removal of gravel, stones, and shingle from sites where they have remained since the Boulder-drift period.

On that arm of Lake Ontario which commences at the outlet of the river Trent, at Trenton, and runs in a zig-zag direction for nearly 90 miles until it meets the main lake near Kingston, named the Bay of Quinte, the waters are frozen over every winter to a thickness of from $1\frac{1}{2}$ to $2\frac{1}{2}$ feet. Near the head of the bay (with which, from a residence of nearly twenty years, I am more especially conversant), and at some period during the season, a crack occurs right across from shore to shore. If this strikes a gravelly shore at either end (as it frequently does), the ice forming the crack being lifted up on each side, gravel, shingle, or stones may be seen imbedded in the ice which has thus been lifted up. These have been taken from the shallows by the ice coming into contact with them. This shows the effect of such ice on a shallow gravelly shore where the water is not more than from 1 to 2 feet deep. And hence it may be concluded that, not only from such shores, but also from muddy ones, earth, sedge, and other matters are transported to new localities at the breaking up of the ice in the spring, when the waters rise by the melting of the snows; and thus we have a present geological agent acting powerfully every season in the removal of gravel, stones, boulders, and earthy matter to distant spots.

In the rapids of the rivers in Canada loose cakes of ice, named flood-, anchor-, or pack ice are formed; and in the river Trent these, being formed thus a short distance above the deep water of that river's mouth, either pile up in a high mass on the solid ice below, or find their way under it, and, floating down to the bar near the mouth in the bay, there eventually dam up the waters more or less, and occasionally flood the banks. A large flood of this kind inundated the lower streets of the village of Trenton in January 1867; and the water freezing forthwith, there was a layer or stratum of ice of over a foot in thickness there for the rest of the winter. A flood of this extent is of unfrequent occurrence, however, and the ice barrier generally gives way before the waters rise to this level. From a similar cause the lower part of the city of Montreal was flooded by an accumulation of anchor-ice from the

Lachine rapids at the Victoria tubular railway bridge two or three seasons back. And again a similar flood occurred in the winter of 1869.

But the most striking example of the action of anchor-ice that has come to my knowledge is that of Crab Island, situated in the midst of the River St. Lawrence, about 3 miles above the town of Cornwall. This island was situated between Barnhast's Island and Cornwall Island. Mr. George Barnhast, a man far advanced in years, being over eighty years of age, well remembers this island. When he first knew it, its extent was about an acre and a half; but he could plainly see, from the shoal-ground, that it must formerly have consisted of at least five or six acres. He had gathered wild grapes (*Vitis vulpina*) upon the island when a boy; and there were many bushes and small trees upon it at that time. Another old resident also tells me that he remembers its being about an acre in extent. Now Crab Island has entirely disappeared, though a strong ripple still indicates where its foundation or basis remains, though year by year the water is becoming deeper. The Rector of Cornwall, Archdeacon Patten, who kindly drew my attention to this fact, and furnished me with its early history, says, "Within my recollection, the water was shallower over it; and when I first came to Cornwall (now 24 years ago), rafts of timber coming down the St. Lawrence were continually grounded upon it, whereas now it is a very unusual occurrence for one to be grounded there."

Mr. G. Barnhast says the ice is the chief cause of the island's removal. The anchor-ice accumulates in great quantities at the foot of the Long Sault rapids at St. Regis Island, at the western entrance of Lake St. Francis, in the smooth water, until at length it forms a dam across the whole river, which in consequence sets back until the rapids above become smooth water. The river then rises until it at times reaches 20 or 25 feet, inundating the adjoining elevated Long Sault or Cornwall Canal, until immature icebergs are formed of floes; then the dam gives way, and the water suddenly subsides. These ice-accumulations often topple over, carrying with them masses of earth and boulders imbedded in them. By such masses Crab Island was gradually carried away piecemeal. And Mr. Barnhast states that he remembers one large rock above water that was at length tumbled into the deep water below. In like manner, from the rapids above his house on Barnhast's Island, the ice has brought down boulders and deposited them on the level space before his house, where several still remain.

The upper surface of the islands in this portion of the St. Lawrence is Postpliocene and Boulder-drift, lying over chalky sandstone strata of the Lower Silurian (Trenton) series. Within the precincts of the town of Cornwall, there is a large and dense accumulation of marine shells, chiefly *Saxicava vagosa*, *Leda portlandica*, *Mya arenaria*, &c., which still exist in the Gulf of St. Lawence. But this deposit, chiefly in sand, is at least 700 feet above the level of the sea. And the burial-ground of the parish church, with the structure (the Bishop Strachan memorial church), is situate in

ne midst of this deposit; and from every new grave opened there numbers of these shells, and more especially the first and third named above, are thrown out. The length of the whole Long Sault Rapids, from Long Sault Island to two miles below Cornwall at St. Regis Island is over eighteen miles.

---

9. *On the* Physics *of* Arctic Ice, *as* Explanatory *of the* Glacial Remains *in* Scotland. By Robert Brown, of Campster, M.A., Ph.D., F.R.G.S., &c.

(Communicated by Professor Ramsay, LL.D., F.R.S., F.G.S.)

Contents.

In touching again on the subject of Arctic ice-action and Glacial remains in Britain, I am well aware that I am risking the stirring up of a hardly subsided degree of controversy most disquieting to the peace of mind of men unwilling to enter the lists of combatants. Of late years, however, the subject has received new light from the hypothesis, propounded first, I believe, by Agassiz[1], that Scotland and other portions of the north of Europe were at one time covered with an icy mantle, and that it is to this, and not to the agency of floating ice, that the glacial[2] markings and remains so abundantly scattered over our country are due. More recently still, this theory, at one time so violently opposed, has been brought into almost universal favour by the publication of the fact that Greenland is at this day exactly in the condition in which Agassiz, reasoning on observed facts, hypothetically described North Britain to have been. This new start has been chiefly due to the writings of Dr. Heinrich

[1] Edin. New Phil. Journ. vol. xxxiii. p. 217; Proc. Geol. Soc. vol. iii. p. 327.

[2] I use the word "Glacial" as expressing all relating to ice, on sea or land; while the word glacier is, of course, used in the ordinary acceptation of the term.

Rink, of Copenhagen (formerly one of the naturalists of the royal Danish war-vessel 'Galatea,' in her voyage round the world under the command of Admiral Steen-Bille, but, until recently, and for many years previously, Royal Inspector of South Greenland), translated in the 'Journal of the Royal Geographical Society'[1], though the facts were known long previously to his placing them before English geographers in a clear light. Accordingly, thanks to the labours of Smith of Jordanhill[2], Lyell[3], Chambers[4], Milne-Home[5], Darwin[6], Fleming[7], Murchison[8], Peach[9], Jamieson[10], Ramsay[11], Thomas Brown[12], Crosskey[13], Page[14], McBain[15], Howden[16], Jolly[17], Archibald Geikie[18], James Geikie[19], and many other geologists, we are in possession of a body of facts which enable us to reason on the subject with a degree of certainty which would otherwise have been impossible. First, then, it will be necessary to examine in a concise manner the subject of the present glaciation of Greenland and other Arctic countries, and ice-action generally.

Previously to doing so, I may say that I have enjoyed opportunities of studying ice-action in British Columbia, Washington Territory, Oregon, California, &c., and on the Western and Eastern shores of Davis Straits and Baffin's Bay—that I have voyaged over the seas of Spitzbergen and Greenland—that I have passed a whole

[1] Vol. xxiii. p. 145 (1853); Proc. of Soc. vol. vii. p. 76 (1863).

[2] Quart. Journ. Geol. Soc. vol. vi.; Memoirs of the Wernerian Natural History Society, vol. viii.; and 'Newer Pliocene Geology.'

[3] Proc. Geol. Soc. vol. iii.; 'Antiquity of Man;' 'Elements' and 'Principles,' &c. &c.

[4] 'Ancient Sea Margins,' and Edin. New Phil. Journ. 1853 & 1855.

[5] 'Coal-fields of Mid-Lothian;' Trans. Roy. Soc. Edin. vol. xvi.; *ibid.* vol. xxv. 1869, &c.

[6] Phil. Trans. 1839.

[7] 'The Geological Deluge, as interpreted by Baron Cuvier and Prof. Buckland, inconsistent with the testimony of Moses and the Phenomena of Nature;' 'Lithology of Edinburgh,' &c.

[8] Brit. Assoc. Rep. vol. xx.; Proc. R. G. S. vol. vii. 'Russia in Europe,' &c. &c.

[9] Proceedings of the Royal Physical Society Edin. 1861; Edin. New Phil. Journ. n. s. vol. ii. &c.

[10] Quart. Journ. Geol. Soc. vols. xiv. xvi. xviii. xix. and xxiv.

[11] Quart. Journ. Geol. Soc. vol. xviii.; 'Glaciers of Wales,' &c.

[12] Trans. Roy. Soc. Edin. vol. xxiv.

[13] Trans. Geol. Soc. Glasgow, vols. ii. & iii.

[14] Various systematic publications, &c.

[15] Proc. Roy. Phys. Soc. Edin. 1859–1862.

[16] Proc. Roy. Phys. Soc. and Trans. Geol. Soc. Edin. vol. i.

[17] Trans. Geol. Soc. Edin. vol. i.

[18] 'Scenery of Scotland;' Edin. New Phil. Journ. 1861; Trans. Geol. Soc. Glasgow, vols. i. iii. &c.

[19] Trans. Geol. Soc. Glasgow, vol. iii. That this list by no means exhausts the names of those who by their writings have advanced the subject, or contains all the papers of those mentioned, is self evident. The names of Bald, Imrie, Hall, MacCulloch, Dick-Lauder, Trevelyan, J. D. and E. Forbes, Hibbert, Maxwell, Prestwich, Maclaren, Craig, Landsborough, Mackenzie, Jas. Thomson, Nicol, Cumming, Cleghorn, Smith, Miller, Hopkins, Brickenden, Bryce, Martin, Hall, Macintosh, Murphy, Lubbock, the Duke of Argyll, and others are familiar as having done good service; but I have only referred to the papers which have come immediately before me.

summer in the Danish possessions in Greenland, at a post situated in close proximity to the great ice-fjord of Jakobshavn, one of the chief sources of icebergs in Mid-Greenland—and that with my companions (Messrs. E. Whymper, A. Tegner, C. Olswig, and J. Fleischer, and an intelligent Eskimo, since dead, named Amak, a native of Claushavn) I attempted a journey over this great interior ice-cap, travelling on foot further than any of the party. I may, however, mention that in 1867 we were not far enough north, or early enough in Davis Straits, to see any thing of the action of sea-ice, and that, though I saw the "inland ice" close at hand for the first time that year, yet I added nothing to the knowledge which my observations during a much more extended voyage along the northern shores of Greenland and the Western shores of Davis Straits enabled me to gain as early as 1861. Accordingly many of these descriptions are written almost verbatim from my notes of that date, and the views I now enunciate were formed at that period also. I am, in addition, not ignorant of the remains of the glacial period in Scandinavia and Great Britain, as well as in North America and other countries. Though the facts here narrated will, in almost every case, be wholly derived from my own observation, I wish it to be distinctly understood that I do not present them as any thing new, but solely as the observations and conclusions of an independent student of the subject, and as therefore of some value. If some of the facts here related are already familiar to the reader from other sources, I can only plead that few, if any, of them are yet sufficiently well understood, or received into the commonwealth of knowledge as confirmed facts, not to admit of being repeatedly described by independent observers.

I. Glacier-system of Greenland.

Greenland, if Petermann's not unreasonable hypothesis regarding its connexion with Wrangell's Land, north of Behring's Strait, is not to be received, is in all likelihood a large wedge-shaped island, surrounded by the icy polar basin on its northern shores, and with Smith's Sound, Baffin's Bay, Davis Straits, and the Spitzbergen, or Greenland Sea of the Dutch, "the old Greenland Sea" of the English whalers, completing its insularity on its western and eastern sides. The whole of the real *de facto* land of this great island consists, then, of a circlet of islets, of greater or less extent, circling round the coast, and acting as the shores of a great interior *mer de glace*—a huge inland sea of freshwater ice, or glacier, which covers the whole extent of the country to an unknown depth. Beneath this icy covering must lie the original bare ice-covered country, at a much lower elevation than the surrounding circlet of islands. These islands are bare, bleak, and more or less mountainous, reaching to about 2000 feet; the snow clears off, leaving room for vegetation to burst out during the short Arctic summer. The breadth of this outskirting land varies, as do the spaces between the different islands. These inlets between the islands constitute the fjords of Greenland, and are the channels through which the overflow of the interior ice discharges it-

self. It is on these islands, or outskirting land, that the population of Greenland lives, and the Danish trading-posts are built—all the rest of the country, with the exception of this island circlet, being an icy, landless, sea-like waste of glacier, which can be seen here and there peeping out in the distance. On some of the large and more mountainous islands, as might be expected in such a climate, there are small independent glaciers, in many cases coming down to the sea, and there discharging icebergs; but these glaciers are of little importance and have no connexion with the great internal ice-covering of the country. I have called the land circling this interior ice-desert "a collection of islands," because, though many of them are joined together by glaciers, and only a few are wholly insulated by water, many of them (indeed, the majority) are bounded on their eastern side by this internal inland ice; yet, whether bounded by water or by ice, the boundary is perpetual, and whatever be the insulating medium, they are to all intents and purposes *islands*.

1. *The interior Ice-field.*—This is well known to the Danes in Greenland by the name of the "inlands iis;" and though a familiar subject of talk amongst them from the earliest times[1], it is only a very few of the "colonists" who have ever reached it. The natives everywhere have a great horror of penetrating into the interior, not only on account of the dangers of ice-travel, but from a superstitious notion that the interior is inhabited by evil spirits in the shape of all sorts of monsters.

Crossing over the comparatively narrow strip of land, the traveller comes to this great inland ice (fig. 1, *a*). If the termination of it is at the sea, its face looks like a great ice wall: indeed the Eskimo call it the *Sermik soak*, which means this exactly. The height of this icy face varies according to the depth of the valley or fjord which it fills. If the valley is shallow the height is low, if, on the contrary, it is a deep glen, then the sea-face of the glacier in the fjord is lofty. From one thousand to three thousand feet is not uncommon. In such situations the face is always steep, because bergs are continually breaking off from it; and in such situations it is not only dangerous to approach it, on account of the ice falling, or the wave caused by the displacement of the water, but from the great steepness of the face it is rarely possible to get on to it in such situations[2]. In such places Dr. Rink has generally found that it rises by successive terraces to the general level plateau beyond[3]. However, where it does not reach the sea, it is often possible to climb on it from the land by a gentle slope, or even in some cases to step up on it as it shelves up. Once fairly on the inland ice, a dreary scene meets the view. Far as the eye can reach, to the north and to the south is this same great ice-field, the only thing to relieve the eye being the wind-

[1] "Interioribus ob plagam glacialem continuam inhabitabilibus." Fabricius, *Fauna Grœnlandica*, 1780.

[2] The "great glacier" of Humboldt is merely such an exposed glacier-face, though of great extent.

[3] Kane calls this the "escaladed structure" of the Greenland glacier. 'Arctic Explorations' (American ed.), vol. ii. p. 284.

ing black circuit of the coast-line land or islands before described, here and there infringing in little peninsulas on the ice, there the ice dovetailing in the form of a glacier on the land, and now and then the waters of a deep fjord penetrating into the ice-field, its circuit marked by the black line of coast surrounding it on either side, the eastern generally being the ice-wall of the glacier, the western being the sea. Travelling a short distance on this interior ice, it seems as if we were travelling on the sea. The land begins to fade away behind us like the shore receding as we sail out to sea; while far away to the eastward nought can be seen but a dim clear outline like the horizon bounding our view. The ice rises by a gentle slope, the gradient being steeper at first, but gradually getting almost imperceptible[1], though real. In the winter and spring this ice-field must be covered with a deep blanket of snow, and the surface must then be smooth as a glassy lake; but in the summer, by the melting of the snow, it is covered with pools and coursing streams of icy-cold water, which either find their way over the edge, or tumble with a hollow sound through the deep *crevasses* in the ice. How deep these crevasses go, it is impossible to say, as we could

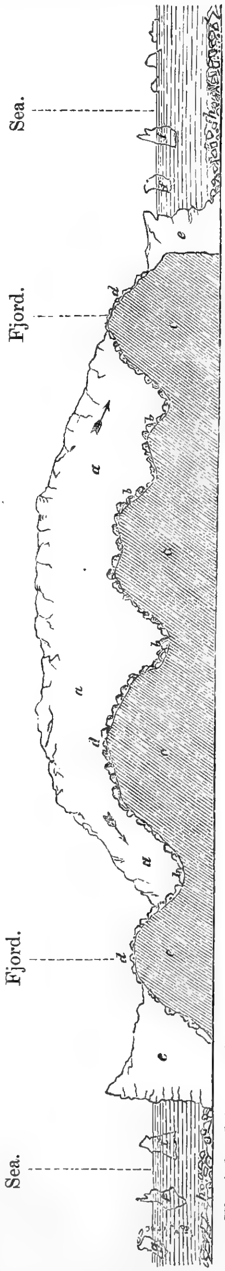


Fig. 1.—*Diagrammatic Transverse section of Greenland from E. to W. in about lat.* 69° *N.*

a. The inland ice overlaying the whole interior of the country. *b.* The "moraine profonde." *c.* The underlying country, now concealed by the inland ice. *d.* The present coast (the "outskirts"), covered with old sea-bottom. *e.* Iceberg in process of formation; *i. e.* the glacier has protruded into the sea, ground along the bottom, but the buoyancy of the sea has not yet floated off the berg. *f.* Icebergs floating off. *g.* Iceberg capsizing and depositing carried moraine on *h*, the present sea-bottom, composed of Boulder-clay, angular travelled blocks, &c.

N.B. The glacier commonly does not reach the open sea *directly*, but enters a fjord, though, for the sake of showing its termination, in the diagram it is portrayed as if reaching the open sea at once. The two arrows show the direction of the outflow of the inland ice (*a*).

[1] During the present summer, between the 19th and 24th July, Prof. Nordenskjöld and Hr. Berggren travelled thirty geographical miles on the inland ice. The point where they turned back was about 2000 feet above the sea.

not see to the bottom of them, nor did the sounding-cord reach down except a short way. The depth of the ice-covering will of course vary; when it lies over a valley it will be deeper, over a mountain-top less. All we know is, that just now it is almost level throughout, hill and dale making no difference. However, with such a huge superincumbent mass of ice, the average height of the coast-lying islands is greater than that of the inland ice, and it is only after climbing considerable heights that it can be seen[1]. Therefore supposing this covering to be removed, I think the country would look like a huge shallow oblong vessel with high walls around it. The surface of the ice is ridged and furrowed after the manner of glaciers generally; and this furrowing does not decrease as we go further inland; on the contrary, as far as our limited means of observation go, it seems to increase; so that even were it possible to cross this vast icy desert on dog-sledges when the snow is on the ground, I do not think it would be possible to return, and its exploration would require the aid of a ship on the other side. On its surface there appears not a trace of any living thing; and after leaving the little outpouring offshoot of a glacier from it, the dreariness of the scene is not relieved by even the sight of a patch of earth, a stone, or aught belonging to the world we seem to have left behind. Once, and only once, during our attempt to explore this waste did I see a faint red streak, which showed the existence of the red snow plant (*Protococcus nivalis*); but even this was before the land had been fairly left. Animal life seems to have left the vicinity; and the chilliness of the afternoon breeze, which regularly blew with piercing bitterness over the ice-wastes, even caused the Eskimo dogs to crouch under the lee of the sledge, and made us, their masters, draw the fur hoods of our coats higher about our ears[2]. Whether this ice-field is continuous from north to south it is not possible in the present state of our knowledge to decide; but most likely it is so. The American explorer Hayes[3] penetrated in upon it in Smith's Sound, with the same results that we did in mid Greenland and off Disco Bay, while Kielsen[4], Rink, and other Danish officers have seen it stretching continuously north and south from where they observed it in South Greenland; so that every fact seems to bear us out in our belief that no transverse ranges of mountains, or land of any extent, break the latitudinal stretch of this "inland ice." Whether its longitudinal range is continuous is more difficult to decide, though the same observers we have quoted saw nothing to the eastward to break their view; so that, as I shall immediately discuss, there seems every probability that in Greenland there is one continuous unbroken level field of ice, swaddling up in its snowy winding-sheet hill and valley, without a

[1] In Rink's 'Grönland,' ii. p. 2, are two characteristic views of the appearance of the interior ice seen from such elevations.

[2] For description of the effects of the ice in limiting animal and vegetable life *vide* the author's "Mammalian Fauna of Greenland," Proc. Zool. Soc. Lond. 1868, p. 337; and "Florula Discoana," Trans. Bot. Soc. Edin. vol. ix. p. 440.

[3] 'Open Polar Sea.'

[4] Rink's 'Grönland Geographisk og Statistisk,' part iii. (vol. ii.) pp. 97–99.

single break for upwards of twelve hundred miles[1] of latitude and an average of four hundred miles of longitude, or from Cape Farewell to the upper extremity of Smith's Sound, and from the west coast of Greenland to the east coast of the same country, a stretch of ice-covered country infinitely greater than ever was demanded hypothetically by Agassiz in support of his glacier-theory.

2. *The Defluents of this inland ice-field.*—Are there any ranges of mountains from the slopes of which this great interior ice descends? As I have said, we are not in a position to decide; but the probabilities are in favour of the negative. There are no iceberg "streams" on the east coast of Greenland; and bergs are rare off that coast. If there were many icebergs, the field of floe-ice which skirts that coast, and which has prevented exploration except in very open seasons, would soon be broken up by the force with which the bergs, breaking off from the land, would smash through the ice-field and, acting as sails, help, by the aid of the winds, as elsewhere, to sweep it away. I am therefore of opinion that the great ice-field slopes from the east to the west coast of Greenland, and that any bergs which may be seen on that coast are from local glaciers or from some unimportant defluent of the great interior ice. Nor do I think a range of mountains at all necessary for the formation of this huge *mer de glace*; for this is an idea wholly derived from the Alpine and other mountain-ranges where the glacier system is a petty affair compared with that of Greenland. I look upon Greenland and its interior ice-field in the light of a broad-lipped shallow vessel, but with chinks in the lips here and here, and the glacier, like viscous matter[2] in it. As more is poured in, the viscous matter will run over the edges, naturally taking the line of the chinks as its line of outflow. The broad lips of the vessel in my homely simile are the outlying islands or "outskirts;" the viscous matter in the vessel the inland ice, the additional matter continually being poured in in the form of the enormous snow covering, which, winter after winter, for seven or eight months in the year, falls almost continuously on it; the chinks are the fjords or valleys down which the glaciers, representing the outflowing viscous matter, empty the surplus of the vessel. In other words, the ice flows out in glaciers, overflows the land in fact, down the valleys and fjords of Greenland, by force of the superincumbent weight of snow, just as does the grain on the floor of a barn (as admirably described by Mr. Jamieson) when another sackful is emptied on the top of the mound already on the floor. "The floor is flat, and therefore does not conduct the grain in any direction; the outward motion is due to the pressure of the particles of grain on one another; and, given a floor of infinite extension, and a pile of sufficient amount, the mass would move out-

[1] Rink, Journ. R. G. S. *l. c.*, says 800 miles; but throughout his valuable work he only speaks of the Danish portion of Greenland, of which it professes solely to be a description. Jamieson and other writers seem to think that it is only North Greenland that is covered. All the country, north and south, is equally swathed in ice.

[2] While, for the sake of illustration, speaking of ice as 'viscous matter,' I must not be understood as giving support to the 'viscous theory' of glacier motion.

ward to any distance; and with a very slight pitch or slope it would slide forward along the incline." To this let me add that if the floor on the margin of the heap of grain was undulating, the stream of grain would take the course of such undulations. The want, therefore, of much slope in a country, and the absence of any great mountain-range, are of very little moment "to the movement of land-ice, *provided we have snow enough*"[1].

As the ice reaches the coast it naturally takes the lowest level. Accordingly it there forks out into glaciers or ice-rivers, by which means the overflow of this great ice-lake is sent off to the sea. The length and breadth of these glaciers varies according to the breadth or length of the interspace between the islands down which it flows[2]. If the land projects a considerable way into the great ice-lake, then the glacier is a long one; if the contrary is the case, then it is hardly distinguished from the great interior ice-field, and, as in the case of the great glacier of Humboldt in Smith's Sound, the interior ice may be said to discharge itself almost without a glacier. The face of Humboldt's glacier is in breadth about sixty miles. This, therefore, I take to be the interspace between the nearest elevated skirting land on either side. It thus appears that, between the inland ice and the glacier, the difference is one solely of degree, not of kind, though, for the sake of clearness of description, a nominal distinction has been drawn. The glacier, as I have said, will usually flow to the lowest elevation. Accordingly it may take a valley and gradually advance until it reaches the sea. In the course of ages this valley will be grooved down until it deepens to the sea-level. The sea will then enter it, and the glacier-bed of former times will become one of those fjords which indent the coast of Greenland and other northern countries often for many miles; or these may be much more speedily produced by depression of the land, such as I shall show is at present going on. By force of the sea the glacier proper will then be limited to the land, and its old bed become a deep inlet of the sea, hollowed out and grooved by the icebergs which pass outwards, until in the course of time, by the action of a force which I shall presently describe (§ 4), the fjords get filled up and choked again with icebergs, in all probability again to become the bed of some future glacier stream[3]. Where there is no fjord at hand, or where these defluents are not sufficient to draw off the surplus supply of ice, the "inland ice" will "boil" over the cliffs, overflowing its basin, and appear as hanging glaciers, whence every now and again huge masses of ice (the aërial

[1] Quart. Journ. Geol. Soc. xxiv. 1865, p. 166.

[2] Properly speaking, according to the ordinary nomenclature, the whole of the ice, from the "névé" downwards, should be called "glacier;" but as we have not yet penetrated sufficiently far into the interior to observe where the "névé" ends and the "glacier" begins, I have for the sake of distinctness adopted the above arbitrary nomenclature.

[3] The origin of fjords is more fully developed in a memoir by the author on "The formation of Fjords, Cañons, Benches, &c.," in Proc. Roy. Geog. Soc. vol. xiv. 1869; Journal, vol. xxxix.; and in his "Das Innere der Vancouver Insel," Petermann's 'Geographische Mittheilungen,' 1869, pp. 94, 96.

equivalent of the bergs) are detached, as the attraction of gravity overcomes the cohesiveness of the ice. These have been seen and described by Dr. Kane on many parts of the Arctic coast. I noticed them in the shape of "miniature glaciers between the cliffs" (Trans. Bot. Soc. ix. 13) at Sakkak, lat. 70° 0′ 28″ N., and on the Waygatz shore of Disco Island. In this latter locality they were the overflow of the inland ice *of the island.* They are also seen in the little local glaciers, where the bed they move in is shallow, and the seaward or outward end high, as near Omenak, where, however, I did not see them, but depend for my information on intelligent Danish officers resident in that section. In Alpine regions away from the coast, the glacier, as it pushes its way down into warmer regions, either advances or retreats according to the heat of the summer; but in either case it gives off no great masses of ice from its inferior extremity. The same is true of the Arctic glacier when it protrudes into some mossy valley without reaching the sea; but when it reaches the sea another force comes into operation. We have seen (1) the inland ice-field emptied by (2) the glacier; we now see the glacier relieving itself by means of (3) the iceberg or "ice mountain," as the word means.

3. *The Iceberg.*—When the glacier reaches the sea (fig. 1, *e*) it grooves its way along the bottom under the water for a considerable distance; indeed it might do so for a long way did not the buoyant action of the sea stop it. For instance, in one locality in South Greenland, in about 62° 32′ N. lat., between Fredrikshaab and Fiskernæsset, or a little north of the Eskimo fishing-station of Avigait, and south of another village called Tekkisok, is a remarkable instance of this. Here the "Iisblink," or the "ice glance," of the Danes (*i. e.* the projecting glacier—though English seamen use the word iceblink in a totally different sense, meaning thereby the "loom" of ice at a distance), projects bodily out to sea for more than a mile. The bottom appears to be so shallow that the sea has no effect in raising it up; and the breadth of the glacier itself is so considerable as to form a stout breakwater to the force of the waves. It was long supposed that the iceberg broke off from the glacier by the mere force of gravity; this is not so. It is forced off from the parent glacier by the buoyant action of the sea from beneath. The ice groans and creaks; then there is a crashing, then a roar like the discharge of a park of artillery; and with a monstrous regurgitation of waves, felt far from the scene of disturbance, the iceberg is launched into life. The breeze which blows out from the land, generally for several hours every day, seems, according to my observation, to have the effect of blowing the bergs out to sea; and then they may be seen sailing majestically along in long lines out of the ice-fjords. Often, however, isolated bergs or groups of bergs will float away south or north. Bergs from the ice-streams of Baffin's Bay will be found in the southern reaches of Davis Straits, while others, bearing débris which could only have been accumulated in South Greenland, will be found frozen in the floes of Melville Bay, or Lancaster Sound. It is a common mistake,

but one which a moment's reflection would surely dissipate, that bergs found in the south must all have come from the north, and that those further north must have come from the regions still farther northward. The winds and the currents waft them hither and thither, until by the force of the waves they break into fragments and become undistinguishable from the oozy fragments of floes around them. Often, however, they will ground either in the fjord or outside of it, and in this position remain for months, and even years, only to be removed by pieces calving or breaking off from them, and thus lightening them, or forced off the bank where they have touched bottom by the force of the displaced wave caused by the breaking off of a fresh berg. Ice much exposed to the sea only breaks off in small ice-calves, but not in bergs. This calving will sometimes set the sea in motion as much as sixteen miles off. The colour of the berg is, of course, that of the glacier; but by the continuous beating of the waves on it the surface gets glistening. The colour of the mass is a dead white, like hard-pressed snow, which in reality it is, while scattered through it are lines of blue. These lines are also seen in the glacier on looking down into the crevasses, or at the glacier-face, and are in all probability caused by the annual melting and freezing of the surface-water of the glacier. Then another fall of snow comes in the winter; then the suns of summer melt the surface to some slight extent; this freezes, forming an ice different in colour from the compressed snow-ice of the glacier, and so on. I am aware, however, that this is a subject of controversy; and this view of mine is only brought forward as a probable explanation, suggested to me as far back as 1861, when I first saw glaciers in the upper reaches of Baffin's Bay and on the western shores of Davis Strait, and long before I was aware that this streaked or veined character of glacier-ice had been a subject of dispute.

The greater portion of these bergs form long "streams" opposite their "ice-fjords," these streams being constantly reinforced by fresh additions from the land, poured out from the fjord. Hence certain localities in Greenland are distinguished by their "ice-streams," these localities being invariably opposite the mouths of ice-fjords, or fjords with great glaciers at their landward end pouring out icebergs. Few, if any, as I have already stated, are found on the east coast; but on the west (or Davis Strait and Baffin's Bay side, from south to north, in the Danish possessions) the following localities, chiefly known by their native names, are situated:—

		° ′
1. Sermilik ice-fjord and ice-stream in about	N. lat.	60 30
2. Sermeliarsuk................	,,	61 32
3. Narsalik	,,	61 57
4. Godthaab	,,	64 30
5. Jakobshavn	,,	69 12
6. Tossukatek	,,	69 48
7. Great Kariak	,,	70 26
8. Little Kariak	,,	70 36
9. Sermelik	,,	70 41

10.	Itifliarsuk	in about N. lat.	70° 52′
11.	Innerit	„	70 56
12.	Great Kangerdlursoak	„	71 25
13.	Upernivik	„	72 57[1]

We have now sketched the ice-field with the glacier and the iceberg. Are there no other defluents of the "inland ice"? This leads us to speak of:—

4. *The Subglacial Stream.*—What is under the inland ice is, I fear, a question we shall never be able to answer. No doubt the country is undulating; for, I believe, this immense glaciation overspread the country after the close of the Tertiary period, perhaps about the same period when Scotland lay under the ice cap. Continuously grinding over these rocks, a creamy mud must be formed, which mud must now be of considerable thickness if not swept into hollows or washed out from beneath the ice. In the Alps the glacier is said to wear for itself a muddy bed, which Agassiz[2] calls *la couche de boue* or *la boue glaciaire*, and other authors *la moraine profonde* (fig. 1, *b*); so that, I think, there can be little doubt that the Greenland inland ice has triturated down a similar clayey bed. However, another instrument in the arrangement and, if I may use the term, "utilization" of this mud, this *moraine profonde*, comes into play. Rink[3] has calculated the yearly amount of precipitation in Greenland in the form of snow and rain at 12 inches, and that of the outpour of ice by its glaciers at 2 inches. He considers that only a small part of the remaining 10 inches is disposed of by evaporation, and that the remainder must be carried to the sea in the form of subglacial rivers. These subglacial rivers are familiar in all alpine countries, and in Greenland pour out from beneath the glacier, whether it lies at the sea or in a valley, and in summer and winter. He also mentions a lake adjacent to the outfall of a glacier into the sea, which has an irregularly intermittent rise and fall. "Whenever it rises, the glacier-river disappears; but when it sinks, the spring bursts out afresh,"—showing, as he thinks, a direct connexion between the two. Arguing from what has been observed in the Alps, he concludes that an amount of glacier-water equivalent to 10 inches of precipitation on the whole surface of Greenland is not an extravagant hypothesis; and he accounts for its presence partly by the transmission of terrestrial heat to the lowest layer of ice, and partly by the fact that the summer heats are conveyed into the body of the glacier, while the winter cold never reaches it. The heat melts the surface-snow into water, which percolates the ice, while the cold penetrates a very inconsiderable portion of the glacier, whose thickness exceeds 2000 feet. As in the alpine glaciers, these subglacial rivers are thickly loaded

[1] Rink: Om den geographiske beskaffenhir af den Danske Handels districter, i Nörd Grönland (Afskrf. af Vidensk. Selskab. Skr. 5 B–3 B), *et lib. cit.*

[2] Etudes sur les Glaciers et Système Glaciaire, p. 574.

[3] Naturhistorisk Tidsskrift, 3rd series, vol. i. part 2 (1862), and Proc. Roy. Geogr. Soc. vii. 76.

with mud from the grinding of the glacier on the infrajacent rocks—in fact, from the washings of the *moraine profonde*. This stream flows in a torrent the whole year round, and in every case which I know of (in the Arctic Regions) reaches the sea eventually, though, no doubt, parting on the way with some small amount of its suspended mud. After it reaches the sea it discolours the water for miles, finally depositing on the bottom a thick coating of impalpable powder. When this falls in the open sea it may be scattered over a considerable space; but when (as in most cases) it falls in narrow long fjords, it collects at the bottom, shoaling up these inlets for several miles from their heads, until, in the course of time, the fjord gets wholly choked up, and the glacier seeks another outlet or gets choked up with bergs, which slowly plough their way through the deep banks of clay, until they get so consolidated together as to shut off the land altogether [1]. Supposing that the deposit only reaches 3 inches in the year, there is a bank or flat 25 feet thick formed in the course of a century. However, any one who has seen these muddy sub-glacier streams, and the way in which they deposit their mud, must be convinced that this estimate is far below the mark, and that an important geological deposit, which has never been rightly accounted for (if even noticed, as far as my observation goes), is forming off the coast of Greenland and wherever its great glaciers protrude into the deep quiet fjords. It ought also to be noticed that the fjords which have been the scenes of old ice-streams, in almost every instance end in a valley at the head, this valley being due, *first*, to the glacier which reclined on it and hollowed it out, and, *secondly* and further down, to the filling up of it by the glacier-clay. This form of fjord is not only common in Greenland, but also in every other part of the world where I have studied their form and formation.

After carefully examining and studying this clay, *I can find no appreciable difference between it and the brick-clay, or fossiliferous Boulder-clay.* Mr. Milne Home [2], among other arguments against the theory that Boulder-clay has been formed by land-ice, remarks that he saw nothing forming in Switzerland at all comparable to Boulder-clay. Reserving to ourselves a doubt on that subject, I can only say that long after my opinion regarding the identical character of the subglacial-stream clay and the fossiliferous brick-clay was formed, a very illustrious Scandinavian Arctic explorer visited Edinburgh, and declared, as soon as he saw the sections of Boulder-clay exhibited near that city, that this was the very substance he saw forming in the Spitzbergen ice-fjords. Many theoretical writers, however, confound the ordinary non-stratified azoic clay, and the finer, stratified fossiliferous clay.

In this clayey bed the Arctic Mollusca and other marine animals find a congenial home, and burrow into it in great numbers. How-

[1] I am glad to find that, independently, this identical view is held by Mr. J. W. Tayler, who resided for several years in Greenland, Proc. Roy. Geogr. Soc. vol. v. p. 90 (1861).

[2] Trans. Roy. Soc. Edin. vol. xxv. p. 661.

ever, as new deposits are thrown down, they keep near the surface, to be able to get their food; so that, if to-day a catastrophe were to overwhelm the whole marine life of the Arctic regions, it would be found (supposing by upheaval or otherwise we were able to verify the fact) that the animals would only be imbedded in the upper strata of clay, and that the bottom one, with the exception of a few dead shells, would be azoic; yet I need not say how erroneously we should argue if, from this, we drew the inference that, at the time the bottom layers or strata of this laminated clay were formed, there was no life in the Arctic waters, or that they were formed under circumstances which prevented their being fossiliferous. The bearing of this on the subject in question need scarcely be pointed out. It ought to be noted that, supposing we were able to examine the bottom of the Arctic sea (Davis Straits, for instance), it would be found that this clayey deposit would not be found over the whole surface of it, but only over patches. For instance, all of the ice-fjords would be found full of it to the depth of many feet, shoaling off at the seaward ends; and certain other places on the coast would be also covered with it; but the middle and mouth of Davis Straits and Baffin's Bay, and the wide intervals between the different ice-fjords, would either be bare or but slightly covered with small patches from local glaciers; yet we should reason most grievously in error, did we conclude therefrom that the other portions of the bottom, covered with sand, gravel, or black mud, were laid down at a different period from the other, or under other different conditions than geographical position. These ice-rivers seem, in the first place, to have taken their direction according to the nature of the country over which the inland ice lies, and latterly according to the course of the glaciers. No doubt they branch over the whole country like a regular river-system [1]. When the glacier reaches the sea, the stream flows out under the water, and,

[1] It may be somewhat superfluous for me to say that these subglacial streams are totally different in nature from the streams which flowed in the old water-courses found under the drift in various parts of the world. These were the beds of the preglacial rivers, and are known to miners as "sand-dykes," "washouts," &c. On the North Pacific slope of the Rocky Mountains they are very common, and are eagerly sought for by the gold-miners, the "old beds" generally yielding a considerable amount of gold. In California, so thoroughly have they been explored by the gold-diggers that, if proper records had been kept, a map of the preglacial rivers might now be drawn, almost as detailed as that of the postglacial or present river-system. The courses of these ancient rivers appear to have been generally in the same direction, and to have had their outlets in the valleys near about the same places as the present rivers. Sometimes these channels seem to cross nearly at right angles. The old Yuba channel, for instance, when its course was interrupted and diverted, ran through the site of the present village of "Timbuctoo," crossing the bed of the present river at Park's Bar; thence running in a north-westerly course, and falling into the Rio de las Plumas (Feather River), near Oroville, a considerable distance from its present junction with that river at Mary'sville. These old channels exhibit the same windings and precipitous falls as the present river; and they have been cut in various places by cañons and ravines; and portions of the older deposit, carried down, mingle with the loose gravel and sand detached by more recent aqueous action.

owing to the smaller specific gravity of the fresh water, rises to the surface, as Dr. Rink describes, "like springs"—though I do not suppose that he considers (as some have supposed him to do) that that water was in reality spring-water, or of the nature of springs. Here are generally swarms of Entomostraca and other marine animals, which attract flights of gulls, which are ever noisily fighting for their food in the vicinity of such places.

We lived for the greater portion of a whole summer at Jakobshavn, a little Danish post, 69° 13′ N., close to which is the great Jakobshavn ice-fjord, which annually pours an immense quantity of icebergs into Disco Bay. In Giesecke's time[1] this inlet was quite open for boats; and Nunatak (a word meaning a "land surrounded by ice") was once an Eskimo settlement. There is an old man (Manyus) living at Jakobshavn whose grandfather lived there. The Tessiusak, an inlet of Jakobshavn ice-fjord, could then be entered by boats. Now-a-days Jakobshavn ice-fjord is so choked up by bergs that it is impossible to go up in boats, and such a thing is never thought of. The Tessiusak must be reached by a laborious journey over land; and Nunatak is now only an island surrounded by the inland ice, at a distance—a place where no man lives, or has, in the memory of any one now living, reached. I believe that this has been mainly owing to the inlet having got shoaled by the deposit of glacier-clay through the rivers already described. I have little doubt that, Graah's dictum[2] to the contrary notwithstanding, a great inlet once stretched across Greenland at this place, as represented on the old maps, but that it also has now got choked up with consolidated bergs. In former times the natives used to describe pieces of timber drifting out of this inlet, and even tell of people coming across; and stories yet linger among them of the former occurrence of such proofs of the openness of the inlet. All that we know is, that such a transcontinental passage, if ever it existed, is now shut up. The glacier and the ice-stream have not changed their course, though, if the shoaling of the inlet[3] goes on (and if the glacier continues at its head, nothing is more certain), then it is just possible that the friction of the bottom of the inlet may overcome the force of the glacier, and that the ice may seek another course. As the neighbourhood is high and rocky, this is hardly possible with the present contour of the land. At the present day, the whole neighbourhood of the mouth of the glacier is full of bergs, and often we should be astonished on some quiet sunshiny day, without a breath of wind in the bay, to see the "ice shooting out" (as the local phrase is) from the ice-fjord, and to wake up with the little bay in front of our door in Jakobshavn Kirke covered with huge icebergs, so that we had to put off our excursion to the other side of the inlet; and the natives would stand hungry on the shore, as nobody would dare put off in his kayak to kill seals, afraid of the falling of the bergs. In a few

[1] "Greenland," Brewster's Encyclop., and App. to Scoresby's Greenland Voyage.
[2] Reise til Oskysten af Grönland, 1832, and transl. 1837.
[3] These inlets are, in fact, the "friths" of these ice-rivers. Indeed the term is actually used by some authors.

hours the bay would be clear, until another crop sprang out from the fjord. At any time it would be dangerous to venture near these bergs; and the poor Greenlander often loses his life in the attempt, as the bergs, even when aground, have always a slight motion, which has the effect of stirring up the food on which the seals subsist. Accordingly the neighbourhood of these bergs is favourable for seals, in the attempt to capture which the hapless kayaker not unfrequently loses his life by falling ice. When we would row between two to avoid a few hundred yards' circuit, the rower would pull with muffled oars and bated breath. Orders would be given in whispers, and even were Sabine's gull or the great auk to swim past, I scarcely think that even the chance of gaining such a prize would tempt us to run the risk of firing, and thereby endangering our lives by the reverberations bringing down pieces of crumbling ice hanging overhead. A few strokes, and we are out of danger; and then the pent-up feelings of our stolid fur-clad oarsmen find vent in lusty huzzahs! Yet, when viewed out of danger, this noble assemblage of ice palaces, hundreds in number being seen at such times from the end of Jakobshavn Kirke, was a magnificent sight; and the voyager might well indulge in some poetic frenzy at the view. The noonday heat had melted their sides; and the rays of the red evening sun glancing askance among them would conjure up fairy visions of castles of silver and cathedrals of gold. Here was the Valhalla of the sturdy Vikings, here the city of the sun-god Freya, Alfheim, with its elfin caves, and Glitner, with its walls of gold and roofs of silver, and Gmile more brilliant than the sun—the home of the happy; and there, piercing the clouds, was Himenberg, the celestial mount, where the bridge of the gods touches heaven[1]. Suddenly there is a swaying, a moving of the water, and our fairy palace falls in pieces, or, with an echo like a prolonged thunder-clap, it capsizes, sending the waves in breakers up to our very feet.

It is most probable that the cause of this "shooting out" of bergs from the ice-fjord of Jakobshavn is due to the force generated by the detachment of a fresh berg from the glacier at the extremity of the fjord. Occasionally, at the time of this "shooting out," the waters of Jakobshavn harbour (a little fjord, the locality of a now extinct glacier) will rise and fall with such tremendous force as to snap a ship's cable. Actually the cable of the 'Marianne,' a brig of 200 tons, was so broken in 1866. This wave is well known to the Greenland Danes under the name of the "kaā-neĕl." Various theories are afloat about it and its cause, which is not very well known; but, as it only happens when the ice is "shooting out" in great quantities, it is most likely caused by the displacement of the volume of water confined in the inlet; and this wave is also felt outside; but its force is lost in the open sea. It is also exhibited at Omenak and other harbours when the ice is shooting out of the ice-fjords in their vicinities; but these harbours being situated at a greater distance from the scene of action, it is not so much felt as at Jakobshavn, close to the ice-

[1] Hayes, *op. c.* p. 24.

fjord. In concluding what I have got to say regarding the subglacial rivers, I cannot help remarking that the effect of this great ice-covering over Greenland must be to thoroughly denude any soft sedimentary strata which might have reclined on the underlying igneous rocks at the time when the whole country got so overspread. Now we know that during the later Miocene epoch the country supported a luxuriant vegetation, as evinced by the remains which I and others have collected from these beds [1]. I was struck, when studying this subject in Greenland, with the fact (though I have no desire to push the theory too far) that the only places where I did not see former ice-action were the very localities where these Miocene beds repose. These localities are a very limited district on either side of the Waygatz Strait, on Noursoak peninsula, and Disco Island, neither of these localities having apparently been overlain at any time by the great inland ice. Noursoak peninsula juts out from the land, and only nourishes small glaciers of its own; and Disco Island is high land, possessing a miniature inland ice or *mer de glace*, with defluent glaciers of its own. If the great inland ice had ever ground over this tract, I hardly think it possible that the soft sandstone, shales, and coal-beds could have survived the effects of this ice-file for any length of time.

5. *The Moraines.*—Moraines are usually classified as *lateral*, *median*, *terminal*, and *profonde* [2], or under the glacier. From the simple character of the Greenland glacier, as described, it will be readily seen that the median moraine, formed by the junction of two lateral moraines, must be rare, while the terminal takes, except in rare instances, another form. Ordinary alpine glaciers, when grinding down between the two sides of a mountain-gorge, get accumulated on their sides rubbish, such as earth, rocks, &c., which fall either by being undermined by the glacier, by frost, or by land-slips, until two lateral moraines are formed. If the glacier anastomoses with a second, it is evident that two of the lateral moraines will unite in the common glacier into a median one. When the glacier terminates, this moraine carried along with it, is deposited at its base, and forms the terminal moraine. Over the lower face of a glacier, according to the heat of the day, some material is always falling, a thimbleful of sand, it may be, trickling down in the stream of water; or a mass of stone, gravel, and earth may thunder over the edge. If the glacier advances, it pushes this moraine in front of it, or, it is possible, may creep over it and carry it on as a *moraine profonde*. This *moraine profonde* consists of the boulders, gravel, &c., which the glacier, grinding along, has carried with it, and which, adhering to its lower surface, help to grind

[1] Heer, in the 'Philosophical Transactions,' 1869, pp. 445–488. In this treatise of Prof. Heer I have printed a few notes on the geology of these Miocene beds; but, owing to an accident, I did not see them in proof. Hence there are several errors. The title of the paper is also apt to mislead. These geological and other points I hope in due course to correct in a full account of the geology of the Waygatz Straits, with illustrative sections, sketches, &c.

[2] The term *moraine profonde* was first used by Hogard in his 'Coup d'œil sur le terrain erratique des Vosges' (1851), p. 10.

down infrajacent rocks and at the same time get grooved in a corresponding direction. If the Greenland glacier does not reach the sea, then the programme of the Alpine glacier is repeated; but when the lower end breaks on reaching the head of the fjord, then a different result ensues. The terminal moraine (*if there is any*; for none comes over the inland ice, which leads me to believe that it does not rise in mountains; and often the glacier is so short as to take little or none from the sides of its valley) floats off on the surface of the iceberg, and the *moraine profonde* either drops into the sea, or is carried further on in the base of the iceberg: very frequently this *moraine profonde* is composed of boulders and gravel, and it is rare that they are not dropped before the berg gets out of the fjord. The berg itself very often capsizes in the inlet and deposits what load it may have on its surface or bottom at the bottom of the sea; and when it gets out of the inlet, as I have already described, it often ranges itself in the outside ice-stream; and if it there capsizes, then the boulders lie on the bottom *there*, so that, if the floor of the sea were raised up, a long line of boulders would be found imbedded in a tenacious bed of laminated clay, with fossil shells and remains of other Arctic animals, skeletons of seals, heaps of gravel here and there, and so on, in what would then be a mossy valley, most likely the bed of some river. Again, allow me to remark that a berg may not capsize by pieces breaking off from above the water, but it may also lose its equilibrium (as is well known) by being worn away, as is most frequently the case, at the base, or (as is less known) by pieces calving off from below. If the berg ground on a bank or shoal, or in any other water not deep enough for its huge bulk to float in, it will often bring up from the bottom boulders, gravels, &c., deposited by former bergs, and carry them on until this material is deposited elsewhere; when grounding, it will graze over the submerged boulders, or rocks just under water, grooving them in long grooves; for an icebeg, it cannot be too often remembered, is merely a mountain of ice floating in the sea. In my earlier voyages in the Arctic regions I was rather inclined to underrate the transporting-power of bergs, as I saw but few of them with any earth, rocks, or other land-matter on them. Though still believing that this has been exaggerated to support their theories by some writers ignorant, unless by hearsay, of the nature of icebergs[1], I am inclined to think that I was in error.

Towards the close of my voyage, in 1861, I had occasion to ascend to the summit of many bergs when the seamen were watering the vessel from the pools of water on their summits; and I almost invariably found moraine, which had sunk by the melting of the ice into the hollows, deep down out of sight of the voyager sailing past, but which would have been immediately deposited if the berg had been capsized. In 1867 I saw many bergs with masses of rocks on them, and only at the mouth of the Waygatz one

[1] I have found, however, that much of the "discoloration" in bergs is caused by the brown leaves of the *Cassiope tetragona* and other plants, growing among the rocks abutting on the glaciers, and blown down upon them.

with a block of trap (?) so large that it looked, even at a distance, like a good-sized house.

6. *Life near the ice-fjords.*—In the immediate vicinity of the Jakobshavn ice-fjord (and I take it as the type of the whole) animals living on the bottom were rare, except on the immediate shore or in deep water; for the bergs grazed the bottom in moderately deep water to such an extent as almost to destroy animal and vegetable life rooted to the bottom. In this vicinity bunches of algæ were floating about, uprooted by the grounding bergs, and the dredge brought up so little material for the zoologist's examination that, unless in deep water, his time was almost thrown away. Again, the heads of the inlets, unless very broad and open to the sea, are bare of marine life, the quantity of fresh water from the subglacial stream and the melting bergs being such as to make the neighbourhood (as in the Baltic) unfavourable for sea-animals. Some inlets are said to be so cold that fish leave them. I have not been able to confirm this in the Arctic regions. When stream-emptying lakes fall into the head of these fjords, having salmon in them, then seals ascend into the lakes in pursuit of them. Other localities, owing to the capricious distribution of life, would be barer or more abundantly inhabited. Again, in shallow inlets, except for Crustacea or other free-swimming animals, the bottom, continually disturbed by the dropping of moraine or the ploughing up of bergs, would be unfavourable for life. Accordingly, if the bed of the Arctic Ocean in these places were raised, and we found the mouth of a valley with laminated beds of clay rich in Arctic shells, and the head bare of life, but still showing that the beds had been assorted by marine action, supposing we were (as in Scotland) ignorant, except by analogy, of the history of this, should we not feel justified in saying that the beds at the one place and the other were deposited under different conditions, and were in all likelihood of different ages? How just that apparently logical inference would be I need scarcely ask.

II. Action of Sea-ice.

We have in the previous section in the most outline form sketched the subject of Greenland glacial action. As the object of this paper is not to form a summary of our knowledge on the subject, I have not entered into a discussion of any points on the physics of ice, further than was necessary to a right understanding of the subject in hand. Suffice it to say that all sea-ice forms originally from the "bay-ice" of the whaler, as the thin covering which first forms on the surfaces of the quieter waters is called, and that this "bay-ice" is entirely fresh, the effect of arctic freezing temperature being to precipitate the salt. Hence, when we talk of the temperature requisite to freeze salt water, it is merely equivalent to saying that this temperature is requisite for the precipitation of the saline constituents of the water. The water of the arctic sea is, according to Scoresby, of the specific gravity 1·0263. At this specific gra-

vity it contains $5\frac{3}{4}$ oz. (avoird.) of salt to every gallon of 231 cubic inches, and freezes at $28\frac{1}{2}$ Fahr. The specific gravity of this ice is about 0·873. To enter upon this subject, of which the above is only the summary of a long series of experiments, is foreign to the object of this paper. From this bay-ice is formed the floe, from the floe the pack-ice and other forms familiar to arctic navigators. In the summer the ice in Davis Strait on either side breaks up sooner than that in the middle of the strait, which remains for a considerable time, forming the "middle ice" of the whalers. Still, however, a narrow belt remains attached to the shore during a considerable portion of the summer. This is called by the Danes in Greenland the "iis fod," and by the English navigators the "ice-foot." As the spring and summer thaws proceed, land-slips occur, and earth, gravel, and avalanches of stones come thundering down on the ice-foot, there to remain until it breaks off from the coast and floats out to sea with its raft-like load of land-débris. As the summer's long sunlight goes on, the ice, worn by the sea, parts with its load; and this may be shortly after its leaving the land, or it may float tolerably far south. The ice-foot, however, rarely carries its load as far south as the mouth of Davis Strait; and sea-ice is seldom seen far out of the arctic regions, while, as we all know, bergs often float far into the Atlantic. Often fields of ice will float along and, like icebergs, graze the surface of rocks only a wash at low tides; and therefore its action might be mistaken for that of icebergs or land-ice. In other cases I have known the ice-foot, laden with débris, to be driven up by the wind and high tides on to low-lying islands, spits, and shores, piling them with the load thus carried from distant localities, so that blocks of trap from the shores of Disco or Waygatz might be drifted up on the beach at Cumberland Sound or on the syenitic shores of South Greenland.

It has even been found that in shallowish water the ice will freeze to the bottom of the sea; and in such situations the gravel, blocks, &c., there lying will freeze in and be carried out to sea, to be deposited in course of time in a manner similar to the superincumbent loads of the ice-foot, though more speedy. The same phenomenon holds good of the Baltic. In the Sound, the Great Belt, &c. the ground-ice often rises to the surface laden with sand, gravel, stones, and sea-weed. Sheets of ice, with included boulders, are driven up on the coasts during storms and "packed" to a height of 50 feet. How easily such sheets of ice, with included sand, gravel, or boulders, may furrow and streak rocks beneath may be imagined[1]. The patches of gravel on the pack-ice are owing, I think, to portions of the gravel-laden ice-foot having got among the ordinary materials of the pack; for I do not think that ice formed in deep water, unless when it passes over rocks, and therefore may take up fragments of stone or earth, has any geological significance.

The conclusions which we are forced to draw from what I have said regarding the depositing-power of glacier-streams, bergs, and sea-ice must be:—1. That the bottom of Davis Strait must be composed

[1] Forchhammer in Lyell's 'Principles,' pp. 231–232.

of *various* materials; 2. That particular materials must predominate in particular localities; 3. That the bottom in the vicinity of ice-fjords and in fjords must be chiefly composed of clay, with boulders, gravel, and earth either scattered over it or in patches; 4. That the mouth and centre of Davis Strait and various banks, such as Rifkol, must be chiefly composed of earth, gravel, boulders, &c., with little or none of the glacier-clay; 5. That life must not be uniformly distributed through this bottom; 6. That though the lines of travelled blocks, boulders rubbed by grounding bergs, ice, or by being brought out as part of the *moraine profonde*, will be found scattered over every portion of the sea, still they will chiefly be found in the lines of fjords and of the iceberg-stream; 6. That the clayey bottom of deep inlets will be little disturbed, while that of shallow ones will be grooved and torn up by grounding bergs, &c.

III. Rise and Fall of the Greenland Coast.

It may be asked—have we any data for the conclusions in the foregoing paragraphs, further than logical inferences from observed facts justify us in drawing? Yes, we have; for there has been a rise of the Greenland coast, laying bare the sea-bottom, as just now there is a fall going on. This fact is not new; on the contrary it is notorious, but has been much misunderstood. We have the Danes telling us on the most irrefragable evidence that the coast is falling, while the Americans who wintered high up in Smith's Sound, saw there raised sea-beaches and terraces, and accordingly say that it is rising in that direction, while in truth, both of them are right, but not in the exclusive sense they would have us to imagine. There *has been* a rise; there *is* a fall going on. We now supply the proofs.

1. *Rise.*—In Smith's Sound both Kane's and Hayes's expeditions observed a number of raised terraces 110 feet above high tide-mark, the lowest being 32 feet. These were composed of small pebbles, &c. Hence they concluded that the coast *was* rising. I think it can be easily enough shown that this is only a portion of the old rise of the Greenland coast. The interval between this locality and the Danish possessions, commencing at 73° N. lat., has been so little examined either by the geographer or the geologist that we can say nothing about it; but more to the south and along the whole extent of the Danish colonies, this raised portion of the sea-bottom is seen. The hills are low and rounded, and everywhere scattered with perched blocks, boulders, &c., many of them brought from northern or southern localities. In other localities, in the hollows or along the sea-shore, we see several feet of the glacier-clay (the "brick-clay" in fact) full of arctic shells such as are now living in the sea, Echinodermata, Crustacea, &c., while in other places, as might be expected from what I have said, the clay is bare of life. This clay corresponds identically in many places with some of the "brick-clays" of Scotland, though, as might be expected from the difference these clays partake of from the different rocks the trituration of which has given origin to them, they are in some places of different shades of colouring. In this

glacier-clay (or shall I call it upper laminated Boulder-clay?) all the shells found are of species still living in the neighbouring sea, with the exception of two, *Glycimeris siliqua,* and *Panopœa norvegica*; but as both of these are found in the Newfoundland sea, we may expect them yet to be shown to be living in Davis Strait[1]. I have seen this "fossiliferous clay" up to the height of more than 500 feet above the sea, on the banks overlooking glaciers. At the Illartlek glacier, in 69° 27′ N. lat., this glacier-clay, deposited on the bottom of the sea by some former glacier, now formed a moraine; and on the surface of the ice I picked up several species of shells which had got washed out by the streams crossing over the glacier face. This Illartlek glacier does not reach the sea; but supposing (as is doubtless the case elsewhere) that this clay had fallen on a glacier giving off icebergs, then the shells deposited in the old sea-bottom would be again carried out to sea, and a second time transferred to the bottom of Davis Strait! I found this clay everywhere along the coast and in Leer Bay, south-west of Claushavn; in knots of this clay are found impressions of the Angmaksaett (*Mallotus arcticus,* O. Fabr.), a fish still quite abundant in Davis Strait[2]. However, though this glacier-clay was found everywhere along the coast, yet it should be noticed that this was chiefly when glaciers had been in fjords, &c., and that often for long distances it would be sparingly found only in valleys or depressions.

Other evidences of the rise of the Greenland coast are furnished by ruins of houses being found high above the water, in places where no Greenlander would ever think of building them now. On Hunde (Dog) Island, in the district of Egedesminde, there are said to be two such houses, and two little lakes with marine shells naturalized in them, and remains of fish-bones, &c., on the shores. I only heard this when it was too late, so that to my regret I had to leave the country without paying a visit to this remarkable locality.

2. *Fall.*—This has been long known; but it is only within the last thirty years that special attention has been drawn to the subject, chiefly by Dr. Pingel[3], who passed some time in Greenland. The facts are tolerably well known, how houses are found jammed in by ice in places where they never would have been built by the natives, as Proven, and so on. It may, however, be as well to recapitulate these proofs.

Between 1777 and 1779 Arctander noticed that in Igalliko Fjord (lat. 60° 43′ N.) a small rocky island, "about a gun-shot from the shore," was entirely submerged at spring-tides; yet on it were the walls of a house (belonging to the old Norsemen) 52 feet in length, 30 in breadth, 5 in thickness, and 6 high. Fifty years

[1] Mörch in Tillæg no. 7 til Rink's '*Grönland,*' Bind 2, S. 143.

[2] "In general, I may say," remarks Agassiz, when speaking of the closeness with which Tertiary fishes agreed with recent ones, "that I have not yet found a single species which was perfectly identical with any marine existing fish, except the little species (*Mallotus*), which is found in nodules of clay, of unknown age, in Greenland." I am convinced that the age I have given is correct.

[3] Proc. Geol. Soc. vol. ii. p. 208.

later the whole of it was so submerged that only the ruins rose above the water. The settlement of Julianeshaab was founded in 1776 in the same fjord; but the foundations of the old storehouse, built on an island called "The Castle," are now dry only at very low water. Again, the remains of native houses are seen under water near the colony of Fredrikshaab (lat. 62° N.). Near the great glacier which projects into the sea between Fredrikshaab and Fiskernæsset, in 62° 32′ N., there is a group of islands called Fulluarlalik, on the shores of which are the ruins of dwellings which are now overflowed by the tide. In 1758 the Moravian *Unitas Fratrum* founded the mission-establishment of Lichtenfeld, about two miles from Fiskernæsset (lat. 63° 4′); but in thirty or forty years they were obliged once, "perhaps twice," to remove the frames or posts on which they rested their large *omiaks* or "womens" (seal-skin) "boats." The posts may yet be seen beneath the water.

To the north-east of Godhaab (lat. 64° 10′ 36″ N., long. 51° 45′ 5″ W.[1]), on a point called Vildmansnæs (Savage Point) by Hans Egede, in 1721–36, several Greenland families lived. These dwellings are now desolate, being overflowed at high tide. At Nappersoak, forty-five miles north of Sukkertoppen (lat. 65° 25′ 23″ N., long. 52° 45′ 25″ W.), the ruins of old Greenland houses are also to be seen at low water.

In Disco Bay I had another curious instance brought under my attention by Hr. Neilssen, Colonibestyrer of Claushavn. The blubber-boiling house of that post was originally built on a little rocky islet, about one-eighth of a mile from the shore, called by the Danes "Speck-Huse-Oe," and by the Eskimo, "Krowelenwak," which just means the same thing, viz. "Blubber-house Island." For many years the island had been gradually sinking, until, in 1867, the year of our visit, Hr. Neilssen had been under the necessity of removing the house from it, as the island had been gradually subsiding until the floor of the house was flooded at high tide, though, it is needless to say, sufficiently far above high-water mark when originally built. On another island in its vicinity the whole of the Claushavn natives used to encamp in the summer, for the treble purpose of drying seals' flesh for winter use, of getting free from disturbance by the dogs, and of getting somewhat relieved from the plague of mosquitoes; but now the island is so circumscribed that the natives do not encamp there, the space above water not allowing of room for more than three or four skin tents. These facts are sufficient evidence that the coast of Greenland is falling at the present time; and I doubt not that if there were observers stationed in Smith's Sound for a sufficiently long time, it would be found that the coast is also falling there, though hitherto only Kane and Hayes have stayed there, but for too short a period to decide on the matter; and I cannot see that there is the slightest reason why the fall should halt at Kingatok (N. lat. 73° 43′),

[1] According to observations by Capt. v. Falbe, of the Royal Danish Navy, furnished to me by Capt. H. L. M. Holm, of the Hydrographic Department, Copenhagen.

the most northern Danish post, and the most northerly abode of civilized man. Circumstances have only allowed of its being noted so far[1].

Hr. Neilssen told me that he considered that Disco Island, opposite Claushavn, was rising, because the glaciers were on the increase. I think that if there is no more evidence than this for that supposed fact, we may lay it aside as erroneous, because the glaciers are undoubtedly increasing by the increase of the interior *mer de glace* on the island, and by the regular descent which they are making to the sea.

I have made an attempt to estimate the rate of fall; and though we have no certain data, yet I believe that it does not exceed five feet in a century, if so much; so that none of us will live to see Greenland overspread by the sea. Here I may point out what seems to be a fallacy in the reasoning of those authors who write about the denuding power of rivers, and calculate that such and such a country will be overwhelmed by the sea in so many millions of years. Whatever the land loses by denudation the sea gains; and therefore the two forces keep pace with each other. We thus see in Greenland two appearances: (1) In the interior what Scotland once was; (2) on the coast what Scotland now is. We will therefore proceed in conclusion to point out some of the similarities in the latter light.

IV. Application of the Facts regarding Arctic Ice-action as explanatory of Glaciation and other Ice-remains in Britain.

Scattered over Scotland and the northern portion of England, and part of Ireland, are blocks of stone and grooved boulders on the top of high hills, or down in valleys. These boulders generally take the line of valleys. All over the country, also, is found a coarse clay or earth, mixed with boulders, rocks, &c., pell-mell, and above it another, finer clay, also with boulders, but stratified, and in many localities abounding with fossil shells, these shells being species now living in the Arctic Sea. I need hardly remind the reader that this is the Boulder-clay, the Northern drift, or by whatever other name it is known. In the eastern counties of England it consists of gravel with fragments of various rocks; in the midland counties, of dark tenacious clay or "till," with boulders; and wherever found, these clays &c. are almost always *local*; *i.e.* they partake in character of the district over which they lie, in colour, texture, and admixture of the underlying formations. In addition, the rocks are grooved, and the sides and tops of the hills are worn and furrowed as if by some body passing over them. Further than this I do not require to introduce the subject; for it is abundantly well known to all geologists, and its origin is an endless subject of controversy. What my opinion of the origin of these clays &c. is, is already

[1] In the 'Report of the British Association' for 1869 (Exeter Meeting), I have given a summary of the foregoing observations.

evident from what I have said; indeed it is only necessary to get an explanation of the great body of appearances presented by the glacial remains in Scotland to turn the first part of this memoir to this end, and give the description of glacial action in Greenland as an explanation. These explanations I will shortly summarize:—

The glacial clays have received various subdivisions, each geologist subdividing them as best suited the particular theory he was advocating; but the broad one generally adopted is into (1) an under non-fossiliferous one, not due to the action of water, and (2) an upper or fossiliferous one due to marine agency. It is too much the custom among the numerous writers on the 'Glacial Period,' to describe one small locality or district with which they are familiar, and therefrom to deduce the explanation of a phenomenon which must have extended over immense regions. This is most misleading. We must first endeavour to explain the broad features common to every district, and then see if local deviations cannot be explained by mere local peculiarities.

1. *The sub-Azoic Boulder-clay.*—This I consider, with Agassiz, Jamieson, and other authors, not due to the agency of icebergs or marine ice, but as the *moraine profonde*, or the great ice-covering of this country when Britain lay under conditions such as now prevail in Greenland.

2. *The Fossiliferous, Laminated or Brick-clays.*—These I consider are due almost solely to the sub-glacier rivers depositing at the bottom of the sea clay in which mollusca burrowed. This clay was deposited above the "till" when the country sank to the extent of about 500 feet beneath the sea; for beyond that height, in Scotland at least, we have no remains of marine shells. Part of it, I will not deny, may be due to the sea assorting portions of the previous non-fossiliferous till; but that the greater portion of these clays are due to the causes mentioned, from what we see in Greenland I have no doubt. When the fossiliferous Boulder-clay lies directly on the bottom, then we may suppose that during the time the non-fossiliferous clay was forming on land under the glacier the sub-glacier rivers were depositing this mud in the sea. If it is not fossiliferous, then we must conclude either that the old fauna of the Tertiary period had left the sea, and that the arctic one had not taken possession of it, or that this absence of life was due to one or other of the causes I mentioned in sec. 6, p. 688, as causing the clay at present forming in the Greenland fjords to be azoic. Mr. Jamieson, indeed, considers that the fossiliferous clay might have been contemporary with the non-fossiliferous clay underlying it, and that the fauna found in it was really the fauna of the period. If this is true (and I am inclined to believe it), then, unless on the most natural supposition that the one was forming independently from the sub-glacial rivers of the ice cap which was forming the other, I do not see how, on his theory, the one could overlie the other. This fossiliferous clay is, curiously, generally found near the coast, and in localities which, in the glacial epoch, would be the outlets of glacier

streams,—these green grassy valleys being then beds of glaciers; and the gloomy glens scattered with boulders, deep fjords, through which icebergs sailed to the open sea. I consider that the greater portion of the Loess, or Lehm, of the Alpine valleys, and even of France, is due to the same cause (viz. the deposit from the glacier-rivers), and that, in fact, it is identical in character with the laminated fossiliferous glacial clays. It differs from them, however, in this respect, that this clay was spread over alpine valleys without so much assisting power from water as if the rivers had fallen into the sea, was not disturbed by boulders scattered through it, or icebergs ploughing it, but that the land shells found in it are theoretically of the same nature as the marine shells found in the glacial clays, viz. the fauna of the overspread region; much of the loess, however, was doubtless due to the present great continental rivers. In many places (as in Caithness) we only find the upper fossiliferous clay without the under "till;" and in this case I consider that the clay was deposited before a surface with *moraine profonde* was exposed; for be it noted that it was only as the glaciers were clearing off, either by increased heat, or by breaking off in bergs when the country got sunk to the depth mentioned (more or less, it does not matter), that the two clays were formed one above another in the manner described; for only then could the *moraine profonde*, or "till," get exposed for the upper laminated clays to form above it[1].

3. *Kaimes, Escars, Oscars, or Gravel Mounds, &c.*—The glacial clays often contain nests of gravel, and beds of sand interstratifying with the clays. How these were formed can be easily understood by any one who has seen the icefoot and the icebergs scattering their gravel and stones over the bottom; and how certain districts should have gravels and others clay is, in my opinion, equally apparent, because, if the theory enunciated in this paper be correct, then the fossiliferous Boulder-clay could only be limited to certain districts, as in Davis Straits at the present day. The curious ridges of gravel &c. variously designated by the names at the head of this section are, I am strongly inclined to believe, merely the sand- and gravel-banks of the old glacial sea, and are very nearly equivalent to what the present "cod-banks" (Rifkol &c.) in Davis Straits would be if the bed of that sea were laid bare. Against this theory, however, there stands the fact that hitherto no marine remains have been got in these "Kaimes" (as they are called in Scotland, "Eskars" in

[1] Since this was written, a most interesting and suggestive paper has been published by Mr. James Croll "On the Boulder-clay of Caithness as a product of land-ice" (Geol. Mag. vol. vii. pp. 209–214, and pp. 271–278), in which he endeavours, with much plausibility, to prove that this clay is part of the bed of the North Atlantic pushed forward by a huge glacier, which at that time, he considers, filled up the greater part of that sea, the ice from Scandinavia being, he considers, too thick to float in the comparative shallow sea into which it must have protruded either in the form of icebergs or of glaciers. Without giving my adherence to a theory so sweeping, I cannot but admire the logical manner in which Mr. Croll reasons out his hypothesis, and the interest and importance of his suggestion—much too important, indeed, to be discussed in the foot-note with which I must at present dismiss it.

Ireland, "Oscars" in Sweden); so that, unless this stumbling-block be removed, we must consider them due to fresh-water action—this action being still unknown. The mounds on the "Mound Prairie" in Washington territory[1], and also in Texas, are, I am convinced, very similar in their origin, though I doubt if the cause, or causes, engaged in forming them were in any way connected with the glacial period. My eminent friend Professor J. D. Whitney's denial[2] of the presence of the glacial drift on the North Pacific coast (whatever may be said of the region he is personally intimately acquainted with, as Director of the Geological Survey of California) is founded, as far as British Columbia, Washington Territory, and Vancouver Island (so far as I have examined these countries) are concerned, on the imperfect observation of his informant[3], the drift being everywhere well developed in these regions, as I have pointed out in another place[4].

4. *Boulders.*—Boulders scattered over the country are due to the period of the formation of the (non-fossiliferous) Boulder-clay when the country was sunk more than now, as will be afterwards noted in the inferences (§ β); but those lying in the lines of valleys are due to the depositing power of bergs, as these bergs still, as described, deposit them in the originals of these glens and valleys, the Arctic fjords; and hence the boulders keep the lines of the valleys. The boulders and travelled blocks on the top of the highest hills are due chiefly to the transporting power of the great moving "inland ice" of Britain at that period; and the former are really a portion of the *moraine profonde*, which, however, the old rivers (derived from the melting of the glacier-cap) or the subsequent action of the weather have not swept, with the clay around them, into the valleys. These boulders, dragged over the rocks, would act as a file to the underlying strata they came into contact with; so that we need not be surprised that both the rocks and boulders are deeply furrowed.

We must, however, draw a distinction between the different kinds of blocks scattered over the country. Those blocks, rounded, grooved, and worn as if by ice could (in my opinion) be only due to this *moraine profonde*, and are connected with the superincumbent inland ice. The boulders &c. carried off by bergs are not grooved or worn; for they merely drop down on the upper surface of the ice and are carried out to sea, and there dropped. If they are afterwards grooved it must be by the action of ice passing over them and grazing them—an occurrence, I fancy, not very common. That these erratic blocks will get water-worn is only a natural con-

[1] Gibbs, in 'Pacific Railroad Surveys,' vol. i. pp. 469 & 486; Cooper, in the 'Natural History of Washington Territory,' p. 18. These and other physico-geographical features of North-West America will be more fully described in the author's 'Horæ Sylvanæ' now in course of publication.

[2] Proceedings of the California Academy of Sciences, vol. iii. p. 277 (1866).

[3] See also Dall, in 'Silliman's American Jour. of Sc.' Jan. 1868, and Proc. Boston Nat. Hist. Soc. vol. xii. pp. 145, 146.

[4] Petermann's 'Geographische Mittheilungen,' 1869, p. 5; Trans. Geol. Soc. Edin. 1869, p. 19; and 'Silliman's Amer. Journ. of Sc.' Nov. 1870, pp. 318–324.

sequence of their submarine situation; but this is very different from the ice-grooving of the subglacial boulders.

5. *Life in the Old Waters*—The rarity of life in many of the glacial beds need not be wondered at when we consider what I have said regarding the capricious and even sporadic distribution of life in the fjords of Greenland. It is possible also, as Lyell suggests, that animal life was originally scarce; for "we read of the waters being so chilled and freshened by the melting of icebergs in some Norwegian and Icelandic fjords that the fish are driven away and all the mollusca killed"[1]. He also points out most justly that, as the moraines are at the first devoid of life, if transported by icebergs to a distance, and deposited where the ice melts, they may continue as barren of every indication of life as they were where they originated. That the freshening of the water of fjords does destroy or prevent animal life developing, I have already shown; but I doubt whether the chilling has much, if any effect; and the recent researches of Carpenter, Jeffreys, Thomson, and others show that the idea which was suggested, that the sea might then be too deep for animal life, is without foundation; for life seems, as far as our present knowledge goes, to have no zero; besides, the shells found in the glacial formations are not deep-sea shells. Again, we must be careful to avoid concluding that the plant- and animal life on the dreary shores or mountain-tops of the old glacial Scotland was poor. In Greenland, the outskirting islands support a luxuriant phanerogamic vegetation of between 300 and 400 species of plants[2]; the sea is full of fishes and invertebrates, which shelter in forests of Algæ. Plants even ascend to the height of 4000 feet. Millions of seals and whales, and of many species, sport in these waters, or are killed in thousands every spring on the pack-ice or land-floes. Every rock is swarming and noisy with the cries of water-fowl; reindeer browse in countless herds in some of the valleys; the Arctic fox barks its *huc*! *huc*! from the dreariest rocks in the depth of winter; and the polar bear is on the range all the year round. Land-birds from southern regions come here for a nesting-place[3], and from the snowy valleys the Greenlanders will bring in the depth of winter sledge-loads of ptarmigan into the Danish posts. Life is so abundant that the Danish Government find it profitable to keep up trading-posts there, and the collecting and preserving of the skins, oil, and ivory of the native animals afford profitable employment to a considerable population. Independently of the fish eaten, the seals used as food and clothing, and the oil consumed in the country, it may not be

[1] Lyell's 'Antiquity of Man,' p. 268.

[2] The present writer, in little more than two months, amid many other occupations, collected on the shores and in the vicinity of Disco Bay alone, 129 species of flowering plants and vascular cryptogams, more than 40 mosses (39 are described in the paper already mentioned; but several additional have been since detected among the collection), 11 Hepaticæ, more than 100 Lichens, about 50 Algæ, and several Fungi (see 'Transactions of the Edinburgh Botanical Society,' vol. ix.).

[3] About 115 species of birds are found in Greenland.

irrelevant in this light to present the following list of a portion of the annual exports of the Danish settlements in 1855[1]:—

9569 barrels of seal-oil.

47809 seal-skins.

6346 reindeer-skins. There is on record the fact of 30,000 being exported in one year.

1714 fox-skins.

34 bear-skins (the animal being almost extinct in Danish Greenland).

194 dog-skins (in addition to the numerous teams used by the natives).

3437 lbs. rough eider-down.

5206 lbs. of feathers.

439 lbs. of narwhal ivory (the natives also using up much for their implements).

51 lbs. of walrus ivory (the walrus being little pursued).

And 3596 lbs. of whalebone (very few of the *Balæna mysticetus* being killed).

Add to this that, when the Danes came to Greenland first, there was a population not much less than 30,000; and to this day there lives within the Danish possessions a healthy, hearty race of upwards of 10,000 civilized intelligent hunters of narwhal, seal, and reindeer, with schools and churches within sight of the eternal inland ice, and with a long night of four months, which, perhaps, Scotland had not during the glacial epoch. I do not believe, however, that our shores were inhabited then; but still I see no reason why they *could* not have been; and with the bright skies and warm sunshiny days of a Greenland summer fresh in my memory, I cannot bring myself to believe in the poetically gloomy pictures pseudo-scientific writers have delighted to draw of the leaden skies, the misty air, and unutterable dreariness of our Scottish shores in that incalculably distant period when glaciers ran through our valleys from the inland ice, and icebergs crashed in our romantic glens, then fjords of that glacial coast.

Thus, in the barest outlines, I have endeavoured to indicate what I believe to be the origin of the different glacier-remains of our own country. Many facts in support of the glacial-ice-cap theory could have been adduced; but as these are already familiar to all geologists, it would merely be a waste of space to repeat them here, especially as this is not intended to be a treatise on glacial remains in Britain.

In closing the paper, I may briefly recapitulate the inferences to be drawn from what we see; and in these inferences I agree almost entirely with Mr. Jamieson, so that it will be only a *résumé* of what he has already, and in a much better manner, described.

[1] For it I am indebted to my friend the Chevalier Rink, now of Copenhagen, the most eminent authority on all matters connected with Greenland. See also my monographs of Greenland Mammals in the 'Proceedings of the Zoological Society of London' for 1868, and in 'Petermann's Geographische Mittheilungen,' 1869.

6. *Inferences from the foregoing Facts*—I conceive that we are justified in concluding from the data which we at present possess that the following were the changes which Scotland underwent during the glacial epoch:—

(α.) That after the Tertiary period the country was covered with a great depth of snow and ice, very much as in Greenland at the present day; but possibly some of the mountain-tops appeared as islands. During this and the subsequent period glaciers ploughed their way down from the inland ice, and icebergs broke off and reached the sea through the glens, then ice-fjords. This glacier-covering must, to a considerable extent, have extinguished the pre-existing fauna and flora, though I do not agree with Mr. Jamieson that the flora and fauna were wholly extinguished. To this period we owe the "till," though I consider that this till was forming also during the subsequent period, and, in fact, as long as the country was swathed in ice and snow. All this period also the laminated clays were beginning to form from the clay-laden subglacial rivers.

(β.) After this the country sank gradually, as Greenland is now sinking, to the depth of several hundred feet; and during this period most of the glacial laminated fossiliferous clays were formed. During this period boulders were deposited from the icebergs broken off from the glaciers of Scotland, as well as from the icebergs and other floating ice drifted both from the north and south, as was also the case during the former (α) period. I consider now that the greater portion of the boulders and other moraine was deposited from *home* bergs; for the fact seems often to be lost sight of by some theorists that bergs broke off from glaciers of the country, as well as floated south from Scandinavia. What the extent of this submergence was is yet *sub judice*. The extent of submergence in Wales seems to have been 1800 feet or more; but in Scotland fossil shells of that period have never been found much above 500 feet, though Mr. Jamieson thinks he saw marine beds as high as 1500 feet. However, until we have more positive evidence, we are justified in concluding that from 500 to 600 feet was the amount of subsidence. It is very suggestive that, on comparing Lyell's Map of Britain sunk 600 feet[1], the very parts under the sea *are almost identically those on which the greatest amount of fossiliferous Boulder-clay is now found.*

(γ.) The country seems then to have emerged from the water, but no doubt slowly, until the glaciers finally left the country, unless, perhaps, as in Norway, in the mountains, though it appears that the rivers, from the melting of the ice and the glaciers themselves, had disarranged the beds considerably, leaving behind them much débris of rocks &c.[2]

[1] 'Antiquity of Man,' p. 287, fig. 40.

[2] Hitherto this has been argued on hypothetical grounds; but since this paper was written, in a memoir read before the Edinburgh Geological Society (May 6, 1869, 'Transactions,' vol. i. p. 330, and 'Geol. Mag.' vol. vii. p. 296), "On two River Channels buried under the drift," by Mr. James Croll, of the Geological Survey of Scotland, this rise has been lifted out of the range of hypothesis into

(δ.) By this time the country was much higher than now, and, the land being connected with the Continent, the bulk of the present flora and fauna crept into it from various quarters, though the alpine plants still kept possession of the higher mountain-regions during a great portion of this epoch. The red deer, the great Irish elk, great wild bull, the musk-ox, the brown bear, and the reindeer in all probability appeared about this time, though I am not altogether sure that some of them did not hold possession of the tops of the mountains even during the period of submergence.

(ε.) A depression now took place, and the estuarine beds or carses of the Scottish rivers were formed. Much of the fossiliferous boulder-clay formed as I have described it is now under the sea; off the coast we continually dredge up remains of its fauna. Man had also by this time got into the country; and it is possible that he was there during the former epoch, having travelled overland from the Continent at a period when the Thames was a tributary of the Rhine, and our other rivers had not settled down in their beds, though for long periods previous to this the general contour of our country was as it is just now, only its boundaries were not settled.

(ζ.) The land after this seems to have risen, in all probability to its present level; for we have no certain evidence that since the dawn of history there were any oscillations of level. These latter changes I have touched but slightly on, as they do not concern our subject so much as the former.

Conclusion.—I have thus given what I honestly conceive to be a correct description of glaciation in Greenland, with logical deductions regarding glaciation in Britain and, by context, in northern Europe. The paper resolves itself into two parts:—1st, fact; 2nd, theory. Still our facts are too few to allow any theory to be more than tentative; and it is only by making frequent ventures, and being content to see our first efforts fail, that we can ever arrive at any conclusions regarding the glacial epoch in Scotland. Though we have a number of so-called facts ready-made to our hand, yet the difficulty is to believe them, simply because the recorders, though perfectly honest and upright, see these facts through a preconceived theory, and, unknown to themselves, twist them into a form which will support their views, and omit (unintentionally) to record the very things most necessary to be observed. I conceive, however, that we are on the right track, and that it is only by long observation of the glacial system of Greenland (because in Spitzbergen the glaciers are on such a small scale as to show us glaciation but imperfectly [1]) that we can ever arrive at a sound knowledge of the

---

that of theory founded on ascertained facts. An ancient river-bed shows that at the time of its formation Scotland must have been at least 260 feet higher than the present level; and the river which flowed in it most likely was a tributary of the Rhine. Whether we can agree with Mr. Croll, however, in believing the glacial "period" to have been a succession of heats and colds, requires further consideration of facts.

[1] Spitzbergen, like all the high Arctic islands of any size, has an "inland ice" and glacier-system of its own; but it is too intersected by fjords and broken

causes of the glaciation or ice-markings of Europe. Nature never works by one means alone, but accomplishes her ends by many agents, all working, each in due proportion, towards the same end. So in these, glaciers have accomplished much, but bergs and sea-ice have also done their part in forming the glacier-remains of Britain and other portions of the world. The fault of all the theorists is to suppose that the means they are advocating—glaciers, bergs, or sea-ice—*alone* accomplished the end in question. If any one can give me a better explanation, then I will gladly give up my own. Only if my *theory* is rejected then my *facts* must be accounted for, and it must be shown how this great deposit of clay, which, as the laws of nature are constant, must have been forming in the glacial epoch, is to be accounted for. There are difficulties in the way; but as the best theory is the one which explains the greatest amount of appearances most reasonably, and as we can only reason regarding the past from what we see going on at present, I humbly submit there is some degree of truth (at least) in the theory I have ventured to submit.

---

10. *On an* ALTERED CLAY-BED *and* SECTION *in* TIDESWELL DALE, DERBYSHIRE. By REV. J. M. MELLO, M.A., F.G.S., &c.

THE object of my present communication is to call attention to an interesting section that has lately been exposed in a quarry on the eastern side of Tideswell Dale in Derbyshire. The locality is exactly pointed out by the words "Tideswell Dale" in the Ordnance Map No. 81, S.E. At this spot it will be seen, by a reference to the map of the Geological Survey, that an outcrop of toadstone occurs. Another outcrop of toadstone is also exposed by the railway-cutting on the right bank of the Wye, opposite Litton Mill; this rock is fully described in the recently published memoir of the Geological Survey relating to this county. Above this are found thinly-bedded limestones; whilst lower down the river the toadstone is wanting, and a considerable thickness of fossiliferous limestone occurs with "thin lenticular partings of shale and red clay." At the bottom of Miller's Dale a toadstone, capped by about 150 feet of limestone, is seen running along the roadside on the left bank of the river; this bed

up into islands to produce any large bergs. Between the north-east point of Spitzbergen and Greenland there are no icebergs until we reach the Greenland coast, where a few of inconsiderable size are found, no doubt formed in some of the East Greenland fjords. *Vide* Chydenius, 'Svenska Expeditionen til Spitsbergen, år 1861, under ledning af Otto Torell,' &c., 1865, for many valuable details on this subject; and some interesting notes by Mr. James Lamont on Spitzbergen in the 'Quart. Journ. Geol. Soc.' (1860), vol. xvi. pp. 150 & 428. Prof. Torell, of Lund, is at present engaged on this subject; and from his researches much new light may be expected to be thrown on the glacial remains of Scandinavia, observations regarding which, by many eminent Scandinavian naturalists, have greatly elucidated the subject. Without being invidious, I may cite Sars's 'Jagttagelser over den Glaciale Formation' (Universitets Program, Christiania, 1860) as being of much value to English students of glacial clays.

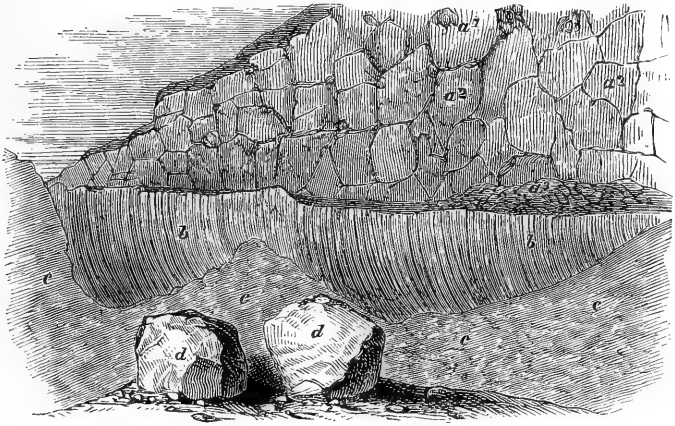
is hard and massive in part, with calcareous veins and hæmatite, and is also amygdaloidal except where it has been exposed to the atmosphere; it is then vesicular and in places much decomposed. An upper bed immediately beneath the limestone is very green and soft, is veined with calcite, and has also here and there a little iron pyrites; the limestone above is very hard, and also has specks of pyrites in it. Going on now up Tideswell Dale by the private road, we soon reach the toadstone mentioned at the commencement of this paper; and this toadstone, I am inclined to think, is of the same age as that opposite Litton Mill, although, as will be shown, it differs from it in some respects.

I will now proceed to describe the rocks as seen in the quarry (fig. 1). Beneath a thin layer of surface-soil on the slope of the hill is a bed of toadstone (a^1); the upper portion of this bed is much broken up and decomposed, and contains curious concretionary balls of all sizes, from that of a walnut up to that of a large cannon-ball; large rounded lumps are also stated to occur in the toadstone opposite Litton Mill. Underneath this upper portion of the rock the toadstone is shattered into large blocks of indefinite shape, yellow outside from the effects of weathering, but within of a very dark green (a^2); this rock is extremely hard and dense, and will readily scratch glass. I have not analyzed it, but should consider it, judging from its appearance, to be a dolerite. In the quarry it attains a thickness of 9 or 10 feet; this passes downwards into a coarse and much decomposed bed (a^3), which is partly amygdaloidal, partly vesicular, and about 2 feet thick: some of its cavities contain wad (earthy binoxide of manganese) in a state of fine powder; others are filled with a mineral which has somewhat the appearance and feel of steatite.

Some of the prisms of the rock next to be described are coated with a mineral which has a similar greasy feel; to this rock I wish to call particular attention. Immediately beneath the toadstone rocks, and without any very apparent sharp line of definition, save perhaps at one part of the quarry (where the boundary line appears rather sharper), lies a thick bed of apparently indurated red clay, at least three yards thick (b). This bed presents a very remarkable appearance, being perfectly columnar or prismatic, the prisms varying in thickness from 5 or 6 inches to about 1 inch, whilst they are about 8 or 9 feet long; their lower ends, however, are not well seen, being buried in *débris*, the prisms readily breaking up and crumbling. At the north side of the quarry (fig. 1) this columnar clay presents a very strange appearance, reminding one, but for the colour of the basaltic rock, of the Giant's Causeway: the columns here attain their maximum thickness, and are well exposed for many yards, contrasting somewhat sharply with the rock above. Their position is nearly vertical, although at the bottom slightly bent. On the western side they are again seen, but are of much smaller diameter, and are inclined at an angle of 64°, whilst a little further on they lie almost horizontally, and present an appearance which was not inaptly described by one of the quarrymen as resembling a mass of corks.

Turning next to the south of the quarry, once again the red prisms are seen at an angle of 38°. This strange-looking rock passes downwards into a coarse greenish-looking bed, composed of fragments of limestone and partings of greenish-yellow clay (*c*); and this forms a "wadding" to a series of very excellent ornamental marbles, which form three principal beds with their partings; these marbles are full of corals, the ramifications of which give them their beautiful variegated appearance.

Fig. 1.—*Section of altered Clay-bed in Tideswell Dale.*



*a*¹. Toadstone with concretionary balls .... ⎫
*a*². " very hard, dark green, and compact ⎬ about 12 ft.
*a*³. " amygdaloidal and vesicular......... ⎭
b. Prismatic (clay?), 9 ft.
c. Clay and Limestone, "wadding."
d. Marble with Corals, facing south.

With regard to the red clay just described, the question which suggested itself to me was, whether it was a greater local development of that before mentioned as occurring in thin partings in the limestone near Litton tunnel. I am not aware of any other locality in the county where the clay is found altered as this is, and partaking of the columnar character, which must have been caused, I presume, by the heating effects of the overflow of the toadstone, and subsequent contraction under pressure. I have seen brick-clay that has, on a small scale, become beautifully prismatic after heating; and we have instances of clays and other rocks being altered and rendered more or less perfectly columnar through proximity to eruptive rocks. I cannot do better, in conclusion, than quote a remark made by Mr. D. Forbes a short time since in reference to the igneous rocks of Staffordshire. He said that "the sedimentary rocks in contact with these were themselves frequently so altered as to present in themselves a columnar structure or jointing, in some

cases quite or even more perfect than in the igneous rock itself; and a bed of clay-ironstone at Ponk Hill was found jointed into regular hexagonal columns by the heating and subsequent cooling and contraction, due to the proximity of the igneous rock which formed the boss of Ponk Hill. Numerous other examples could be cited."

---

11. *Observations on* ICE-MARKS *in* NEWFOUNDLAND. By Staff-Commander J. H. KERR, R.N.

(Communicated by Sir R. I. Murchison, Bart., F.R.S., F.G.S.)

[Abstract.]

WHILST engaged on the survey of part of the coast of Newfoundland, the author observed and noted some of the phenomena produced by the former action of ice. In this paper he enumerated the following localities where grooves and scratches were noticed, and indicated the direction of these markings.

Ice-marks observed in Newfoundland.

No.	Place.	Height in feet above high water.	Direction from true meridian.	
			Grooves.	Scratches.
	CONCEPTION BAY.			
1.	Brigus North Head	50	N. 60° E.	N. 60° E.
2.	James Point	82	N. 38 E.	N. 18 E.
3.	Burke Point	8	N. 47 E.	N. 31 E.
4.	Campbell's Hill	434	....	N. 21 E.
5.	Cat Point	4	N. 43 E.	N. 38 E.
6.	Blue Hills	839	N. 43 E.	
7.	Gastries	8	N. 39 E.	N. 39 E.
8.	Long Hill	458	....	N. 30 E.
9.	Holy-rood, west side	200	....	N. 30 E.
10.	" "	3	....	N. 34 E.
11.	" east side	6	....	N. 26 E.
12.	Bare Shoulder	580	....	N. 34 W.
13.	Butterpot	999	....	N. 7 W.
14.	Topsail Head	650	N. 43 W.	N. 43 W.
15.	Little Bell Island	H.W.	....	N. 38 E.
	ABOUT ST. JOHN'S.			
16.	South side of Harbour	50	....	N. 64 E.
17.	" " "	260	....	N. 64 E.
18.	" " "	360	....	N. 64 E.
19.	" " "	437	....	N. 64 E.
20.	" " "	676	....	S. 86 E.
21.	North side of Torbay	300	....	S. 76 E.
22.	Flat Rock	50–300	....	N. 84 E.
22*a*.	North side, Signal Hill	200–520	....	E.
	NORTH OF BONAVISTA BAY.			
23.	Ladle Island	30	S. 72 E.	
24.	One-Tree Hill (W. side of Pool's Harbour)	190	....	S. 66 E.
25.	Pudding Hill (" " ")	143	....	S. 66 E.
26.	Shoe Hills	360	....	S. 70 E.
27.	Shoe Point	214	....	S. 70 E.
28.	Lewis Island	....	....	S. 88 E.

At Burke Point (No. 3) is a groove 22 feet wide and 20 inches deep, rising out of the water S.W. for a distance of 70 feet over a steep, polished and scratched surface, at an angle of about 40° to the horizon; in this groove there are two sets of scratches, one in the direction of the groove, the other, and more recent one, in a direction N. 31° E. On Campbell's Hill (No. 4) there are numerous boulders, many of them curiously poised. At Cat Point (No. 5) there are grooves on perpendicular surfaces just above the level of the sea, very similar to those occurring on the Blue Hills (No. 6), at a considerable altitude. The west side of Signal Hill, north of St. John's Harbour (No. 22*a*) has the surfaces of the highly inclined strata of coarse sandstone smoothed, grooved, and scratched at all angles of inclination. The marks are lost at the eastern edge of the hill, which forms a precipice 300 feet high, bounding a valley 1000 feet wide, running N.E. and S.W., and they reappear on the opposite boundary of this valley, which rises about 80 feet, and consists of highly inclined strata of coarse conglomerate. After passing over about 1000 feet of this conglomerate, the marks disappear at the sea-shore.

North of Bonavista Bay the granite has the rounded appearance of a glaciated region; but the rock is easily weathered, and the scratches had to be sought under perched blocks. On Ladle Island (No. 23) there is a groove 10 feet wide and 12 inches deep, extending completely across the island (a distance of 200 yards). The surface of the island is formed by the edges of highly inclined beds of schist.

The author discussed the extent and effects of the glacier-system to which these markings are due, and indicated that its great terminal moraine is probably the 80-fathom bank across the mouth of Conception Bay, and that smaller terminal moraines exist in the form of submerged banks at the entrance of Holy-rood and Collier's Bays. He expressed the opinion that the country has not been submerged since its glaciation, and considered that the assertion that it is now rising is exceedingly doubtful.

The paper was illustrated with numerous drawings of localities and rubbings of scratched surfaces.

ALPHABETICAL INDEX

TO THE

PROCEEDINGS OF THE GEOLOGICAL SOCIETY.

[The fossils referred to are described, and those of which the names are printed in italics are also figured.]

THE END.

Printed by TAYLOR and FRANCIS, Red Lion Court, Fleet Street.

THE

QUARTERLY JOURNAL

OF THE

GEOLOGICAL SOCIETY OF LONDON.

EDITED BY

THE ASSISTANT-SECRETARY OF THE GEOLOGICAL SOCIETY.

VOLUME THE TWENTY-SIXTH.

1870.

PART II. MISCELLANEOUS.

CONTENTS OF PART II.

Alphabetically arranged—the Names of the Authors in capital letters.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On the Geology *of* Roumelia. By Prof. F. von Hochstetter.

[Proc. Imp. Geol. Inst. Vienna, November 16, 1869.]

Professor Hochstetter has accompanied M. W. Pressel on a tour through part of European Turkey. The region explored by him occupies an area of about 800 Austrian square miles, stretching through about 80 miles, from the river Morawa to the Bosphorus, with an average width of 10 miles, from the Balkan to the Rhodopi. He distinguishes the following districts :—

1. *The Cretaceous plateau between Rustschuk and Varna.*—The mass of plateaux and flattened mountains, with a maximum altitude of 1200 feet above the sea-level, from the northern base of the Balkan, near Schumla and Razgrad, to Rustschuk on the Danube, is composed of a system of nearly horizontally stratified calcareous marls, green sandstones, and Oolitic limestones. Abundant remains of Cephalopoda (*Belemnites, Ammonites, Baculites, Hamites,* &c.) found in the quarries of Schendeinschick, in a rock exactly resembling the marls of the Plänerkalk, show that these deposits belong to the Cretaceous series. These sub-Balkanian Cretaceous rocks have a northern European type, as has already been remarked by Prof. Peters with regard to the contemporaneous deposits in the Dobrudscha. Well-marked Nummulitic Limestones (described by Capt. Spratt in the Quart. Journ. Geol. Soc. vol. xiii.) occur round Varna, and Sarmatian deposits cover a very limited space in the immediate vicinity of that place.

2. *The Byzantine peninsula* is composed of Devonian strata and of Tertiary Limestones. The latter are of Eocene age at Jarim Burgas, and of Neogene date at Makrikiöi. The range of Tschataldsche rises like an island out of these Tertiaries. Eruptive rocks of Trachytic, Dioritic, and Andesitic nature are conspicuously developed on the shores of the Bosphorus.

3. *The Lower Maritza or Adrianople basin.*—This is bounded on the north by a range formed of Eocene Limestone, resting immediately on gneiss, near Sarai, Visa, Kirklisi, &c. The interior of the basin, which is furrowed by innumerable watercourses, is filled up with Newer Tertiary and diluvial freshwater deposits. Prof. Hochstetter nowhere met with traces of Neogene marine deposits south of the Balkan.

4. *The region of the river Tundscha.*—Between Adrianople and

Jamboli this river runs through an extensive "massif" of granite and gneiss, the summits of which attain an altitude of 3000 feet. Towards the south-west, between Adrianople and Philippopoli, this is connected with the primitive "massif" of Despoto Dagh or Rhodopi.

5. *The eruptive district of Jamboli, Aidos, and Burgas,* situated on the Black Sea, between the "massif" of Tundscha and the Balkan, presents an abundance of Doleritic cones, possessing all the characters of extinct volcanoes, and is connected with very extensive submarine deposits of tuff containing organic remains of Cretaceous character.

6. *The chain of the Balkan.*—A fissure of dislocation running continuously from Burgas, on the Black Sea, to the region of Pirot or Scharkiöi, north-west of Sofia, corresponds with the south slope of the Balkan. From the Black Sea to Sliwno the escarpment or southern slope of the chain is composed of Eocene or Cretaceous deposits, disrupted by porphyries. West of Sliwno, from Tschipka to Karlowa, granite, gneiss, and micaceous and argillaceous slates make their appearance. On the northern border of the basin of Sofia, Triassic sandstones and limestones complete the southern margin of the chain. Hot springs and an almost uninterrupted series of most diversified eruptive rocks mark the course of the chief fissure of the Balkan. The highest summits (6000–7000) feet) are between Sliwno and Sofia.

7. *The Intermediate Mountain-ranges.*—These are the Karadscha Dagh (highest summit 3500 feet) between Eski Saara and Kisanlik, and the Sredna Gora (highest point about 5000 feet) north of Philippopoli. These chains form portions of a granitic and syenitic "massif," which has sunk down between the Balkan and the Rhodopi and become overlain by a series of mesozoic strata.

8. *The Upper Basin of the Maritza* (Plain of Philippopoli).—This is wholly covered with diluvia and alluvia, from which syenitic cliffs (the summits of the sunken "massif") project near Philippopoli.

9. *The Rhodopi or Despoto Dagh.*—This is bounded on the east by the lower Maritza, and on the west by the river Struma (Strymon). Its highest summit rises to 9000 feet; and it forms an extensive primitive "massif" with many eruptive Trachytes of later date, and with local Eocene and Miocene freshwater deposits, some with seams of Brown coal, at an altitude of from 2000 to 3000 feet above the sea-level.

10. *The district of Vitosch.*—The Vitosch mountain is a colossal syenitic "massif," rising 7000 feet above the sea-level. From it the chief rivers of European Turkey (the Maritza, the Struma, the Isker, and the Morawa, or rather its affluent the Nischawa) take their origin. The foundations of this district consist of ancient crystalline rocks, with "massifs" of syenite and granite. A mass of Triassic deposits rests upon them, and is overlain by a vast system of limestones (perhaps Jurassic) interrupted here and there by Cretaceous deposits and newer Tertiary basins with Brown coal.

11. *The small basins along the foot of the Balkan,* such as those

of Jamboli, Sliwno, Kisanlik, Sofia, Dubnitza, Radomir, &c., were occupied by freshwater lakes during the Posttertiary period.

12. *The district of the Upper Morawa.*—This river breaks through lofty crystalline mountain-groups (summits 6000 feet) between Wrangia and Leskowatz. Towards the south-east this group is connected with the crystalline "massif" of the Rhodopi, and consists of gneiss and mica- and clay-slates, with numerous local eruptions of trachyte and rhyolite, swelling into large masses, and connected with vast deposits of tuffs. [Count M.]

On the Occurrence of Fusulinæ *in the Alps.* By Professor E. Suess.

[Proc. Imp. Geol. Inst. Vienna, January 4, 1870.]

MM. Fœtterle and Peters distinguished three members in the Carboniferous formation of the Alps, namely, the Upper and Lower Carboniferous Limestones, and an intermediate member, sometimes containing anthracite, and composed of shales, sandstones, and conglomerates. Prof. Suess accepted this division, which agrees closely with that of the Carboniferous formation in Russia and a great part of North America; and in a communication to the Vienna Academy of Sciences (16 January, 1869) he compared the Upper Carboniferous Limestone of the southern Alps to the Russian *Fusulina*-limestone. This view has now been confirmed by the discovery in the uppermost part of the Carboniferous series in the Canal-Thal at Uggowitz, of a minute broadly ovate fossil which agrees with the *Fusulina robusta* of Meek (Palæont. of California, p. 3). The same species occurs also in the Upper Carboniferous Limestone in the Government of Wologda, where it is accompanied by the smaller elongated form known as *Fusulina cylindrica* (Fischer). In America two or three other species are distinguished.

Prof. Suess remarks upon the wide extension of this *Fusulina*-limestone, which he regards as forming, in the Northern hemisphere, an horizon comparable to that of the Nummulitic limestone of the Tertiary period. In America, it is known in California, Nebraska, Kansas, Missouri, Illinois, and Ohio. *Fusulina cylindrica* occurs in Spain, in the Cantabrian chain, and *F. robusta* in the Southern Alps. In Russia the Limestones containing *Fusulinæ* have a wide extension; and, from the uppermost beds of the Mountain-limestone in Armenia and Azerbeidjan, Abich has described a form, under the name of *F. sphærica*, which Prof. Suess regards as identical with *F. robusta* (Meek). [W. S. D.]

On Ammonites. By Dr. W. Waagen.

Dr. W. Waagen has published (in Benecke's Palæontologische Beiträge, Bd. ii. Heft. 2, 1869) a monographic essay on *Ammonites subradiatus* and the allied forms. He refers to the difficulty which exists, in certain cases, in the use of the binary system of nomencla-

ture, which he regards as increased by the employment of two or more specific denominations. To get rid of this difficulty, and introduce a system which, he thinks, would be expressive of the relations of many forms, he proposes to introduce after the generic name the radical sign ($\sqrt{}$), placing beneath it the name of the fundamental specific form, and above it that of the form supposed to be derived from this by "mutation." Thus the designation (or, as the author calls it, "the genetic formula") of *Ammonites biflexuosus* (D'Orb.) would be as follows:—*Ammonites* $\dfrac{\textit{biflexuosus}\text{, D'Orb.}}{\sqrt{\textit{subradiatus}\text{, Sow.}}}$,—*subradiatus* being the fundamental form, and *biflexuosus* the form derived from it by "mutation."

Dr. Waagen also proposes to divide the genus *Ammonites* into several genera and subgenera, according to the length of the chamber occupied by the animal, the form of the mouth, the presence or absence of the operculum and its nature when present (*Aptychus* or *Anaptychus*), and the sculpture,—the outlines of the lobes being regarded as furnishing only secondary characters, and the general form as of scarcely any importance. The groups founded by him upon the consideration of these characters are the following:—

Genus I. ÆGOCERAS (*Capricorni*, von Buch, commencing in the Muschelkalk with *Amm. incultus*, Beyr., and including *A. planorbis, angulatus, planicosta*, &c.).

Genus II. ARIETITES (the group *Arietes*, best represented by *A. Bucklandi*).

Genus III. AMALTHEUS, Montf. (commencing in the Muschelkalk with *Amm. megalodiscus*, Beyr., and including as Jurassic forms *A. Guibalianus, oxynotus, margaritatus, pustulatus, cordatus, Lamberti*, &c.).

Genus IV. HARPOCERAS (*Falciferi, Flexuosi*, von Buch, *Insignes, Disci, Denticulati*, &c.), with 3 subgenera:—

1. HARPOCERAS sens. str. (Liassic *Falciferi, Insignes*: forms like *A. canaliculatus, trimarginatus*, &c.).
2. OPPELIA (*Flexuosi* and *Tenuilobati*: *A. subradiatus, A. psilodiscus* and its allies).
3. ŒKOTRAUSTES (forms allied to the *Oppeliæ*, but with the body-chamber geniculate: *A. genicularis, dentatus, macrotelus*, &c.).

Genus V. STEPHANOCERAS (*Coronati, Planulati, Macrocephali*, and (?) *Ornati*), with 3 subgenera;—

1. STEPHANOCERAS sens. str. (=*Coronati* and *Macrocepali*).
2. PERISPHINCTES (=*Planulati*).
3. KOSMOCERAS (=*Ornati*).

Genus VI. ASPIDOCERAS (including *A. perarmatus, bispinosus, cyclotus*, &c.). [COUNT M.]